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REGARDING ARMOR AND ITS ATTACK.

By J. B. Van Brussel.

The first suggestion of using armor plate for the protection of ships of war against artillery fire dates from 1805, when an Englishman, Mr. William Congreve, put forward the design of a floating mortar battery of 250 tons displacement, for the attack of coast defenses, which was to be covered with plates and bars of iron, so as to be invulnerable to an enemy's fire. Of these proposals, nothing came however, and the next recorded advocate was John Stevens, of New Jersey, who submitted plans for an armored vessel to the United States government. Some years later a son of John Stevens, after having carried out experiments to ascertain the thickness of iron which would keep out various calibers of shot, submitted to the United States government carefully worked out plans for the application of armor to ships. The matter, however, did not go beyond the experimental stage; but the total destruction of the Turkish fleet by the shell fire of the Russian squadron at the battle of Sinope, November 30, 1853, convinced the various governments of the absolute necessity of forthwith introducing some means of protection, and the following year first the United States and then France and England put in hand armored floating batteries. These had a displacement of from 1,200 to 1,600 tons, a speed of about 4 knots, and were completely ironclad, the thickness of armor varying from 4 inches to 4½ inches of wrought iron, backed by from 24 inches to 28 inches of oak. The armament of the one consisted of 10-inch shell guns, of the other of 68-pounders. The French batteries were almost immediately put to the test of an actual engagement, in the bombardment of Kinburn, during the Crimean war, in 1855, where three of them took a prominent part. After a five hours' cannonade at a range of from 700 to 1,000 yards, the fortress of Kinburn, which mounted 51 casemated guns, was reduced and forced to surrender. On board of the floating batteries the fire of the fortress had caused not the least casualty, and the armor was not penetrated. The advantages of armor were here fully demonstrated, and already in 1861 England and France, and quickly thereafter the United States, had armored seagoing squadrons afloat.

Throughout the American civil war the value of armor was constantly demonstrated, notably in the case of the "New Ironsides," and the "Monitor." Since those days, instances of the value of armor may be multiplied; but it suffices to say that all reliable evidence, including that afforded by the recent Russo-Japanese war, goes to show that armor does not behave in the erratic manner which is sometimes stated, and that proving ground and experimental results may be relied on as guides to what may be expected in action.

There have been disputes as to the best material for armor plates and as to the best disposition for the latter in a ship, with a view to giving the maximum of protection for the latter for the weight at the constructor's disposal, but the value of armor *per se* has seldom, if ever, been seriously questioned.

Even comparatively thin armor gives an advantage, as not only will it keep out high-explosive shell to a great extent, and to a less extent powder-filled common shell, but it will also, unless greatly overmatched, deflect armor-piercing projectiles striking at angles exceeding 40 degrees to the normal. The introduction of armor was, of course, at once met by increasing the power of the gun and the quality and shape of the projectile. This was replied to by thickening and improving the quality of the armor, so that in the twenty years between 1858 and 1878 we find that the thickness of armor increases from 4½ to 24 inches, while the 5½-inch 68-pounder developed into the 16-inch 1,700-pounder, and cast or wrought iron round shot were superseded by chilled iron or steel ogival headed A.P. projectiles. The increased thickness and weight of armor necessitated a corresponding reduction in the armored area, and we pass gradually from the thinly but completely ironclad "Warrior," with a mixed battery of 8-inch and 7-inch guns of 9 and 6½ tons weight respectively, to the "Inflexible," with her small but thickly armored central citadel and her four 16-inch 81-ton tons.

It is about the date of the "Inflexible," 1876-1877, that we find wrought-iron armor being supplanted by steel and compound plates, the former introduced by Messrs. Schneider in 1876, the latter by Mr. Cammell in 1877. Steel was harder, but at the same time more brittle than wrought iron, while the compound plate

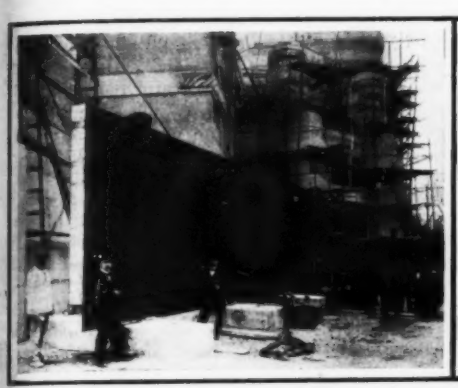


FIG. 5.—TYPICAL CAST-STEEL ARMOR PLATE OF THE LARGEST SIZE EVER PRODUCED.

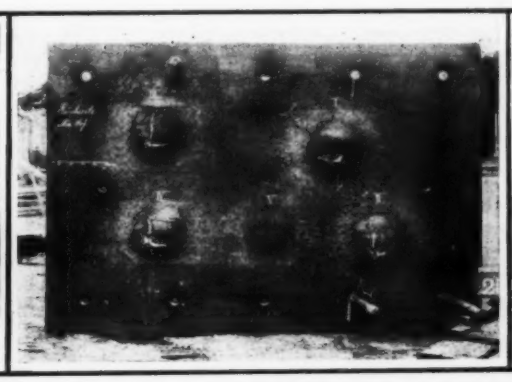


FIG. 2.—REAR VIEW OF THE NICKEL-STEEL ARMOR PLATE SHOWN IN FIG. 1.

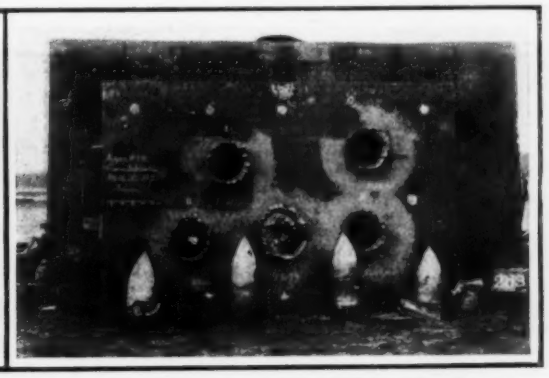


FIG. 1.—FRONT VIEW OF A NICKEL-STEEL PLATE TESTED IN 1892 AT THE KRUPP PROVING GROUNDS.

FIG. 3.—SCHNEIDER-CANET STEEL PLATES FOR BATTLESHIPS.

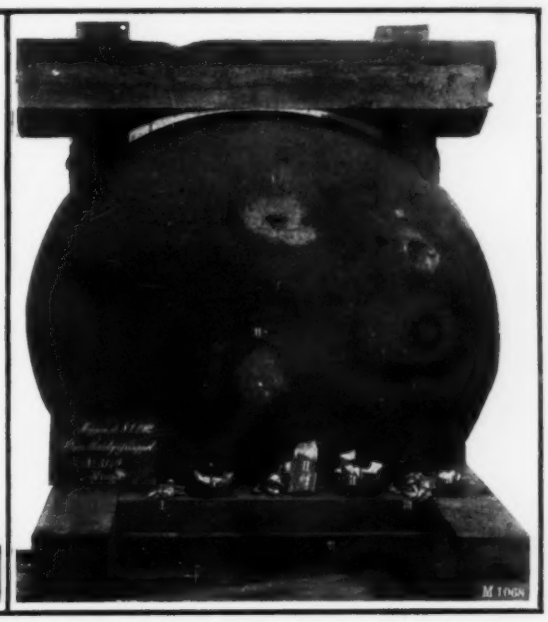


FIG. 4.—TRIAL OF CAST NICKEL-STEEL CUPOLA.

Caliber, 8.4 inches; weight of projectile, 367.6 pounds; velocity, 1,718.6 feet.

REGARDING ARMOR AND ITS ATTACK.

had the advantage of combining a hard-steel face to break up the attacking projectile with a tough wrought-iron back to hold the plate together. Its weakness was, of course, due to its being non-homogeneous throughout, and the surface plate was liable to crack and scale off under attack. The average resisting power of both was, however, much about the same, and may be taken as equivalent to one and one-third times that of wrought iron. For several years compound armor more than held its own against steel, but the manufacture of the latter gradually improved, so that about the year 1890 the best steel plates were probably better than the best compound.

The process introduced by Capt. Tresidder of face-hardening plates, by chilling their heated surfaces with jets of water, raised the resisting power of compound beyond that of the best all-steel armor, but compound plates hardened by this process were almost immediately superseded by steel plates made by the Harvey process, which had the effect of giving a plate of homogeneous material the properties of a hard face and tough back, hitherto only possible by superimposing a hard-steel surface upon a wrought-iron or mild-steel foundation plate. Harvey effected this great improvement by keeping the face of his steel plate for some weeks at a high temperature in contact with carbon. The Harvey and Tresidder processes, which soon became combined, raised the figure of merit of steel plate; further improvements were introduced by Krupp, and so the resistance power of steel plates has ultimately been increased to about two and one-half times that of wrought iron. Nickel steel had first been introduced by Messrs. Schneider in 1889, and was promptly of general use. Our illustrations, Figs. 1 and 2, show front and back views of tests with typical nickel plates at Krupp's proving grounds in 1892 and 1893. Nickel steel combines great tensile strength and hardness with a high elastic limit and great ductility.

The French St. Chamond Works added to this nickel steel a small percentage of chromium, and this combination is now invariably used in Krupp armor; it insures still further the hardness and toughness of the plate. We give the following as a typical analysis, although the composition varies slightly among the various makers:

	Per cent.
Ni	3.50
Cr	1.50
C	0.30
Mn	0.70
Fe	94.00

The modern heat treatment of these nickel-chrome steels in the process of manufacturing an armor plate is a very long and complicated one. The range of temperature at each of the various operations is very limited, and very great care has to be taken to prevent the limits being passed.

Our Fig. 3 shows a test with Messrs. Schneider's special steel plates for battleships.

The majority of the modern armor plates are made under the license of the late Mr. Friedrich Krupp's process, although a few firms are said to use special processes of their own.

There are two kinds of Krupp plate, cemented and non-cemented. The term cementation is applied to the process of superficially carbonizing one side of a plate, with a view of obtaining greater hardness on chilling. The absence of cementation constitutes the only difference between cemented and non-cemented plates, their composition and treatment being otherwise identical. Until comparatively recently, Krupp armor under 5 inches in thickness, and also the curved plates used in structures such as casemates, were not cemented, owing to there being manufacturing difficulties in the way of employing the full process. The difficulty, whatever it may have been, appears to have been overcome to a large extent, and at present the cementation process is applied to curved plates and also to thin plates down to as low a thickness as 3 inches.

The value of the cementing process is at a maximum for plates of about 7 inches in thickness, the figure of merit, which in many cases may be as much as 3, falling off both above and below this point.

One of the principal features of the Krupp process consists in the extreme accuracy with which the material is treated thermally. Great care has to be taken both with regard to the temperature and the duration of the various operations, and at some stages a few degrees one way or the other in the temperature of the steel, or five minutes more or less exposure in a furnace, will make all the difference between a successful plate and a failure. Great vigilance and long practical experience are necessary, if good and uniform results are to be obtained. In addition to these personal qualifications, special and extensive plant of great power and costliness is required for carrying out the process, so that it is not surprising to learn that the cost of the finished product averages about $500 per ton.

A variety of armor which demands notice, although more or less obsolete, is chilled cast iron. It was never used for naval purposes, but at one time it was largely used in the land defenses upon the Continent, in the form of armored cupolas. It was exceedingly hard and practically unperforable, but could be destroyed by fracture, and would crumble away under continuous bombardment of steel armor-piercing projectiles from guns of medium caliber. It was therefore mainly used on sea fronts, where it was admirably suited to resist the few rounds that the heavy guns of battleships might be expected to deliver during an attack of comparatively limited duration.

Its lineal successor is cast-steel armor, specially made by Messrs. Krupp. Our illustration, Fig. 5, shows such a plate, 43.88 feet by 11.33 feet by 12 inches, and weighing over 100 tons.

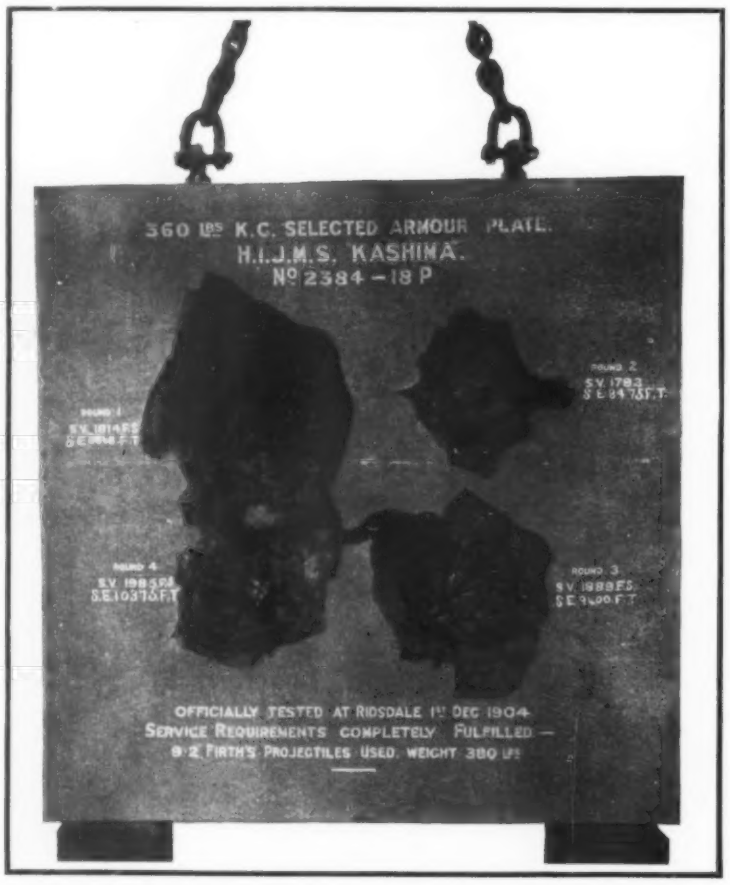

360 lbs K.C. SELECTED ARMOUR PLATE.
H.I.J.M.S. KASHIMA.
Nº 2384 – 18 P
OFFICIALLY TESTED AT RIDSDALE 1st DEC 1904
SERVICE REQUIREMENTS COMPLETELY FULFILLED –
9·2 FIRTH'S PROJECTILES USED. WEIGHT 380 lbs

FIG. 6.—A TRIAL PLATE OF K. C. BELT ARMOR FOR THE JAPANESE BATTLESHIP "KASHIMA" AFTER A SERVICE TEST.

The characteristics of cast-steel armor as regards behavior under attack are, however, very different from those of chilled iron. Although not equal in resisting power to rolled cemented steel plates, this cast armor can nevertheless be made very superior in this respect to ordinary forged steel, and be at the same time of remarkable toughness. It would hardly seem possible, however, for the same regularity of quality to be obtained with cast armor as with forged plates, on account of the extreme difficulty of obtaining heavy castings free from blowholes or other internal flaws. On the other hand, it should be cheaper than forged armor, and quicker to make should time be a consideration. Fig. 4 shows a test at the Krupp testing grounds with a cast nickel-steel armor cupola for land defense. Of course, what precedes is only a very general descriptive account of the processes of modern armor manufacture, as most technical details are held confidential by the manufacturing firms.

As to the attack of armor, its effectiveness depends upon the nature, weight, diameter, velocity, and angle of incidence of the attacking projectile. The armor-piercing projectile of to-day is an ogival-headed cylinder of special hardened and tempered steel. The composition varies according to the manufacturer, but in addition to carbon, it almost invariably contains chromium and usually nickel. The armor-piercer is nowadays usually a low-capacity shell; that is, it contains a cavity which is capable of taking a bursting charge of about 2½ per cent of the total weight of the shell when filled. It is generally made of steel, but some shell are cast. Capped armor-piercing shell of modern type are, as a rule, capable of perforating intact a Krupp cemented plate of a thickness equal to their caliber, at a velocity of 1,800 to 1,900 foot-seconds. Uncapped shot require a considerably higher velocity to defeat a similar plate, and their action is a punching and not a perforating one where hard-faced plates are considered. When attacked, a plate may yield in three ways: It may be fractured and broken up without being perforated, as in the case of chilled iron armor; it may be perforated or bored, as in the case of a relatively soft plate such as wrought iron, when overmatched by a pointed projectile; it may yield by a plug, or more usually, a large coned disk being punched out of it. This is the manner in which the modern hard-faced plate yields when overmatched by uncapped projectiles, and may be looked upon as intermediate in character between the extremes of boring and smashing, but approaching the former rather than the latter. It is noticeable that when the diameter of the attacking projectile is much in excess of the thickness of the plate, the figure of merit of the latter falls off considerably as far as resistance to punching or racking is concerned.

Common shell, which are not strong enough to remain undeformed upon impact, derive no benefit from the cap, and invariably defeat a plate by punching rather than by perforation. High-explosive shell, unless special arrangements are made to delay the bursting charge, and so obviate detonation upon impact, are only effective against the thinnest armor. Within certain limits, the resisting power of all hard-faced plates is very much reduced when the armor-piercing projectiles used in the attack are capped. The cap, which at first was taken up seriously in Russia in 1894, consists of a thimble of comparatively soft steel, of from 3 to 5 per cent of the weight of the projectile, and is attached to the point of the latter. Its function appears to be to support the point on impact, and so to enable it to get unbroken through the hard face layers of the plate. Once through the cemented portion with its point intact, a projectile which is strong enough to remain undeformed will, as a rule, if its striking velocity be high enough, perforate the plate by a true boring action.

We will end our discussion by giving some data regarding a recent test with armor plate.

Fig. 6 shows a trial of 360-pound K.C. belt armor plate for the Japanese battleship "Kashima." The plate measured 8 feet by 8 feet, and the weight was 360 pounds per square foot, or practically equal to a thickness of 9 inches. For the purpose of trial, the plate was backed with 2 feet of oak, to the rear of which, again, was a steel plate representing the ordinary skin of the ship. The attack was by a 9.2-inch gun, using Firth projectiles of 380 pounds. In the first round, the striking velocity was 1,814 feet per second, equal to a striking energy of 8,868 foot tons. This shot penetrated to the extent of one-third of the thickness of the plate (3.1 inches), and there was extensive flaking of the surface above the point of impact. The back was bulged only to the extent of 1.9 inches. The projectile was broken into at least 155 pieces, the largest weighing 35 pounds. The second round was of slightly less power, and had much less effect on the plate, the maximum penetration being only 1.25 inches, but the bulge at the back was 1.5 inches. The third round was a more severe attack than the first shot; striking velocity 1,889 feet per second, striking energy 9,400 foot tons, and there was less flaking, but the penetration was exactly the same.

The bulge at the back of the plate was also of 1.9 inches. In the case of the fourth shot, a still higher velocity was developed, the striking velocity being 1,985 feet per second, giving a striking energy of 10,375 foot tons. The point of the projectile became fused into the plate, and it was thus impossible to measure the penetration, but the bulge at the back was greater than in any of the other instances, being 2.5 inches. As shown in the figure, slight irregular cracks developed, after the firing of the fourth shot, from the center of the damage caused by the first round, but an examination of the back of the plate shows that these cracks were more or less surface effects. At the rear, however, a separate crack was formed, but whether as the result of the more severe attack of the fourth round it is difficult to say. As no through cracks were formed, the results were considered as very satisfactory.

ALCOHOL AND GASOLINE COMPARED.

TESTS MADE BY THE UNITED STATES GEOLOGICAL SURVEY.

THE Technologic Branch of the United States Geological Survey, under the direction of J. A. Holmes, has recently completed an elaborate series of tests on the relative value of gasoline and alcohol as producers of power. The tests, over 2,000 in number, probably represent the most complete and exact investigation of the kind that has been made either in this country or abroad, and includes much original research work. Prof. R. H. Fernald, engineer in charge of the gas producer section, and professor of mechanical engineering in the Case School of Applied Science, Cleveland, Ohio, was in general charge of the tests. R. M. Strong, formerly connected with the engineering department of Columbia University, had personal supervision of the work. He was assisted by a corps of specially-trained men. These tests were conducted at the fuel testing plant of the Geological Survey, at Norfolk, Va., and show the following results in regard to the comparative fuel consumption of 73 degrees specific gravity gasoline and commercial completely denatured alcohol, per unit of power.

Correspondingly well designed alcohol and gasoline engines, when running under the most advantageous conditions for each, will consume equal volumes of the fuel for which they are designed. This statement is based on the results of many tests made under the most favorable practical conditions that could be obtained for the size and type of engines and fuel used. An average of the minimum fuel consumption values thus obtained gives a like figure of eight-tenths of a pint per hour per brake horse-power for gasoline and alcohol.

Considering that the heat value of a gallon of the denatured alcohol is only a little over six-tenths that of a gallon of the gasoline, this result of equal fuel consumption by volume for gasoline and alcohol engines probably represents the best comparative value that can be obtained for alcohol at the present time, as is also indicated by Continental practice. Though the possibility of obtaining this condition in practice here has been thoroughly demonstrated at the government fuel-testing plant, it yet remains with the engine manufacturers to make the "equal fuel consumption by volume" a commercial basis of comparison.

The gasoline engines that were used in these tests are representative of the standard American stationary engine types, rating at 10 to 15 horse-power, at speeds of from 250 to 300 revolutions per minute, while the alcohol engines were of similar construction and identical in size with the gasoline engines.

The air was not preheated for the tests on alcohol and gasoline, and the engines were equipped with the ordinary types of constant level suction lift and constant level pressure spray carbureters. Many special tests with air preheated to various temperatures up to 250 degrees Fahrenheit and tests with special carbureters were made, but no beneficial effects traceable to better carburetion were found when the engines were handled under the special test conditions, including constant speed and best load.

The commercial completely denatured alcohol referred to is 100 parts ethyl alcohol plus 10 parts methyl alcohol plus one-half of 1 part benzol, and corresponds very closely at 94 per cent by volume, or 91 per cent by weight ethyl alcohol (grain alcohol). No detrimental effects on the cylinder walls and valves of the engines were found from the use of the above denatured alcohol.

The lowest consumption values were obtained with the highest compression that it was found practical to use, which compression for the denatured alcohol ranged from 150 to 180 pounds per square inch above atmosphere.

Eighty per cent alcohol (alcohol and water) for use in engines of the present types would have to sell for at least 15 per cent less per gallon than the denatured alcohol in order to compete with it. The minimum consumption value in gallon per hour per brake horse-power for 80 per cent alcohol is approximately 17.5 per cent greater than for the denatured alcohol used or for gasoline. A series of tests made with alcohol of various percentages by volume, ranging from 94 to 50 per cent, showed that the minimum consumption values in gallons per hour per brake horse-power increased a little more rapidly than the alcohol decreased in percentage of pure alcohol—that is, the thermal efficiency decreased with the decrease in percentage of pure alcohol. This decrease in thermal efficiency or increase in consumption referred to pure alcohol is, however, comparatively slight from 100 per cent alcohol down to about 80 per cent alcohol. Within these limits it may be neglected in making the calculations necessary to compare the minimum consumption values for tests with different percentages of alcohol.

The nearer the alcohol is to pure, the greater the maximum horse-power of the engine. The reduction in maximum horse-power for 80 per cent alcohol, as compared with that for denatured alcohol used, was less than 1 per cent, but the starting and regulating difficulties are appreciably increased.

With suitable compression, mixtures of gasoline and alcohol vapors (double carbureters) gave thermal efficiencies ranging between that for gasoline (maximum 22.2 per cent) and that for alcohol (maximum 34.6 per cent), but in no case were they higher than that for alcohol. These thermal efficiencies are calculated from the brake horse-power and the low calorific value of the fuel, which for the gasoline was 19,100 B.T.U. per pound, and for the denatured alcohol was 10,500 B.T.U. per pound.

As has been previously published, alcohol can be used with more or less satisfaction in stationary and marine gasoline engines, and these gasoline engines will use from one and one-half to twice as much alcohol as gasoline when operating under the same conditions. The possibilities, however, of altering the ordinary gasoline engine as required to obtain the best economies with alcohol are very limited, for the amount that the compression can be raised without entirely redesigning the cylinder head and valve arrangement is ordinarily not sufficient, nor are the gasoline engines usually built heavy enough to stand the maximum explosive pressures, which often reach 600 and 700 pounds per square inch. With the increase in weight for the same sized engine designed to use alcohol instead of gasoline comes an increase in maximum horse-power of a little over 25 per cent, so that its weight per horse-power need not be greater than that of the gasoline engine, and probably will be less.

The work was taken up to investigate the characteristic action of fuels used in internal combustion engines with a detailed study of the action of each fuel (gasoline and alcohol), as governed by the many variable conditions of engine manipulation, design and equipment.

These variables were isolated, so far as was possible; their separate and combined effects were determined; worked out under practical operating conditions, and lead up to the conditions required for minimum fuel consumption. The results show the saving that can be obtained over conditions for maximum consumption, and also establish a definite basis of comparison under conditions most favorable to each fuel. This latter is a point of much commercial interest, and a study of the comparative action of gasoline and alcohol may be of great service in solving some of the general internal combustion engine problems where other than liquid fuels are used.

A large number of fundamental tests were necessary in order to clearly define conditions and interpret results. In a way they follow the work conducted by the Department of Agriculture, supplementing to a certain extent, but not duplicating Bulletin 191, which gives much data of general value.

Many of the tests of internal combustion engines have been made, but most of them, especially in this country, were by private concerns, for a specified purpose, and the results are not generally available. Furthermore, as is generally recognized by those familiar with gas and especially gasoline engine operation, the conditions influencing engine performance are so numerous and varied as to make the value of off-hand comparison very limited, and oftentimes misleading, exact comparisons only being possible under identical conditions or with reference to the actual and known differences in all conditions that could influence the results.

With a view to supplying the continually increasing demand for more complete and exact information concerning the operation and design of gasoline and alcohol engines, and to assist the government and others interested in the larger and more general internal combustion engine problems, this investigation was made. —The Iron Age.

THE UTILIZATION OF MEERSCHAUM WASTE.

THE dust produced, as well as the chips resulting from the making of the genuine meerschaum heads, are carefully collected and serve for the production of imitation meerschaum, which in quality closely approximates the genuine article.

According to Th. Urban, the waste of genuine meerschaum is stamped down with water in a barrel. Then the coarse paste is transferred to a mill, consisting of two stones, loosely placed one above the other, where it is ground much finer. Hereupon the slime is rubbed into larger tubs through cloths stretched over them, by the hands. Then this fine cream is thoroughly boiled with linseed oil, alum being added.

The linseed oil imparts to the artificial meerschaum the peculiar polish of the genuine article; the alum, on the other hand, serves as a binding medium.

The boiling being concluded, the meerschaum is poured into molds and allowed to remain in the drying room until the water present is completely evaporated and it has assumed about the consistency of hard soap. Having reached this stage it can easily be brought into any shape and can readily be worked with a knife.

The form of the head being roughly imparted, the turning process on the lathe is next undertaken. The heads are then dried in drying apartments at 60 deg. to 70 deg. R. (169 deg. to 190 deg. F.) and then boiled in melted kidney suet. After cooling, they are rubbed off with shave grass. The best kinds after rubbing down are dipped in boiling spermaceti or wax, which insures more rapid coloring when smoked and imparts greater solidity. Just as popular as the white meerschaum heads, are those that are burned black inside and out, and which are distinguished by their beautiful polish. To produce them, the white heads are allowed to lie ¼ to ½ an hour in boiling linseed oil. After this, they are held so long over burning pine chips until they are black or dark colored, after which they acquire their special polish.

An inferior quality is the red variegated meerschaum head, or oil head, which is made by first boiling the carved head in oil, then scraping and rubbing it and finally subjecting it to a decoction. The red variegated color is produced by adding to the linseed oil some dragon's blood; according to whether a dark or light color is desired more or less dragon's blood is added. Carmine, gamboge, and alcanna are also used as coloring substances.

The imitation heads—made from waste—are also made with carvings. The carving is done in the half-boiled condition and the heads are then subjected to a second boiling.

J. S. Hyatt, Paris, has invented a process of producing a plastic substance from meerschaum waste, nitrocellulose, and camphor.

In the production of certain articles which in form and size considerably exceed the dimensions of the raw meerschaum fragments, we can use real meerschaum as well as the waste when we take into consideration that the cost of treating and forming this composition is considerably less than that of the method at present in use of carving the article from the lump.

The method employed is as follows:

We first pulverize the waste, in any desired manner, to a fine dust. Then we prepare a solution, consisting of about five parts by weight of nitrocellulose and about three to five parts of camphor, by adding a sufficient quantity of ether, about three parts, and of alcohol about one part, or other fluids in which nitrocellulose is soluble, to produce a thick fluid mass. The above-mentioned approximate proportions of these four substances have, under practical test, given excellent results, but are not to be regarded as absolute and can be changed according to the nature of the raw materials and the objects to be produced, within certain limits. Thirdly, we add to the solution thus obtained, the above-mentioned pulverized meerschaum, in the proportion of 100 parts of meerschaum to 5 parts of the nitrocellulose contained in the fluid. Fourthly, we mix the whole, in any desired manner, thoroughly; and last, fifthly, we evaporate, by natural or artificial

means, the superfluous solvents. Sixthly, we again pulverize the mass, and the powder thus obtained is the mass which can be made use of in the production of a large number of articles; for this purpose it is loaded into molds made of metal or some other suitable material, and heated to a temperature of 212 deg. to 242 deg. F.—Translated from the German of Dr. Theodor Koller in the "Handbuch der Verwerthung, etc., von Abfallstoffen jeder Art."

ELEMENTS OF ELECTRICAL ENGINEERING.—XVI.

ALTERNATING CURRENT MOTORS. PART 2.

BY A. E. WATSON, E.E., PH.D., ASSISTANT PROFESSOR OF PHYSICS IN BROWN UNIVERSITY.

Continued from Supplement No. 1685, page 246.

IN the preceding chapter it was mentioned that a series wound direct current motor, with laminated field magnet, would run, though not well, on simple alternating current circuits. The reasons for the "not ing," have of late been carefully scrutinized, and means found for eliminating them in a fairly satisfactory degree. Just what the troubles and their appropriate remedies are will be explained at some length in the latter part of this chapter.

The original series motors offered for use on alternating currents were for desk fans only, and a rather curious modification of connections of such little motors is well worth noting. If the connection between armature and field be removed, and the brushes short-circuited on themselves, but given considerable lead, the armature will run with the alternating current connected to the field alone. See Fig. 69. The explanation is that the alternating magnetic flux from the field induces secondary currents in the armature coils that are favorably situated, and then repels those coils; as soon, however, as the first coils have been pushed along, the action of the brushes and commutator continually presents other coils for similar repulsion. This is therefore known as the "repulsion" type of motor. It has characteristics of operation resembling those of the ordinary series type. Recently some attempts have been made to resuscitate this construction, and develop it for railway traction, but the results seem conclusively to indicate that it is much the inferior of the two.

Another form of the repulsion motor is one in which all the armature coils have one connection in common with a ring, while the other ends connect with the separate segments of a commutator. The ring is close to the ends of the segments, and a single brush is wide enough to extend across the ring and commutator. By this device current is allowed to flow in a single coil, and then this one is pushed along until another takes its place. A serious defect in this arrangement consists in the fact that only a small part of the armature winding is in use at a given instant. Rather a novel spectacle is presented by this commutator-collector single-brush device.

The reality of this repulsive action can well be brought out by energizing a large straight laminated-core electro-magnet with alternating currents, and suspending a copper ring in front of one of the ends. In the lack of a better piece of apparatus, an ordinary spark coil may be tried, the flow of current being controlled by lamps used for resistance. The ring will always turn edgewise to the end of a magnet, so as not to embrace any lines of force; for just as soon as some other position is taken, lines of force will thread through the ring, and induce in it currents always in the direction to be repelled. By using liberal sized

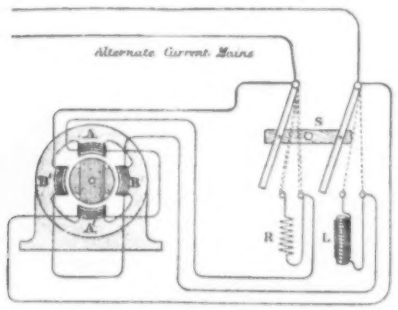


Fig. 70.—Two-Phase Motor on Single-Phase Circuit, with Phase-Splitting Device.

coils, the repulsion can be made very energetic, and if the copper ring be of wire bent around and soldered, the joint will quickly be melted. It will be recognized that this is merely a transformer action, the electromagnet windings being the primary, and the ring the secondary. In the case of the repulsion motor, the lead given to the brushes preserves a certain obliquity of position of the active coils, so as to allow for the successive production of these secondary currents.

After the invention of the highly successful two-phase and three-phase induction motors, it was shown that somewhat similar constructions would operate on single-phase circuits, that such motors would be cheaper to build, longer lived, and of higher efficiency

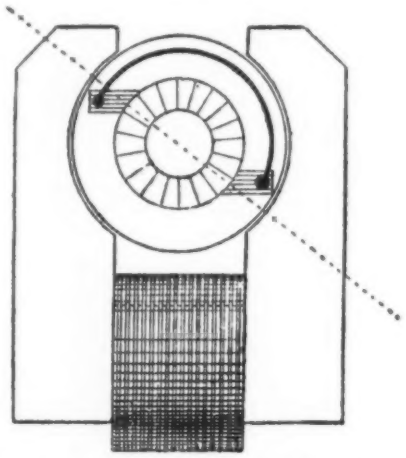


Fig. 69.—Alternating Current Repulsion Motor.

than those employing commutators. The solution of this problem lay in the principle now known as "splitting" the phase. Since one of the effects of self-induction in a circuit is to produce a lag of the current behind the electro-motive force, it is obviously possible to provide two circuits in parallel with each other, one of which has a minimum and the other considerable inductance. Then when connected to a single-phase supply, the current will flow in one of these paths at a later instant than in the other. If these are the two circuits of a two-phase motor, a slight imitation of the rotary field magnetism of such machines will be produced. It would be futile even to aim for full 90 degrees difference in phase relations, for then, in accordance with Fig. 56 of Chapter XIII., the lagging current would exert no power. Just enough inductance is introduced to enable a start, however feeble, for when synchronous speed is approached the torque enormously increases. This device of separating a single alternating current into two components differing in phase is due both to Ferraris and Tesla, and was first used by them in 1889. A diagram of a two-phase motor, in which the pole windings are all similar, with exterior starting arrangements, and a single-phase supply is given in Fig. 70. An ohmic resistance, R, represented by zig-zag lines, is included at the start in one circuit, while an inductive resistance, L, represented by a coil on an iron core, is in the other. Coils A and A' will therefore be energized by current lagging behind the electromotive force by the amount due to their own inductance, while in coils B and B' there will be the further lag due to the interposition of the extra inductance L. After attaining a good speed, the switch is moved still further, thereby cutting out both these resistances, and allowing both windings to operate in parallel. Though apparently with four poles such a field has essentially only two, the sub-division into four parts being merely to accommodate the two phases. Synchronous speed would be attained only when acting as a two-pole machine. Recognition of this point is evinced by the winding shown on the rotor, consisting of two broad short circuited bands of wire; each band is wound diametrically, a familiar requirement for direct current armatures to fit a two-pole field magnet. In the particular diagram given, A and B' finally combine to produce one pole, while A' and B make the other.

A modification of this split-phase arrangement is to let the poles A and A' embrace considerably more of the rotor, with the coils B and B' wound on their tips; for starting, these latter coils are short-circuited by closing a small switch, and then, when full speed has been attained, removed from circuit. The objection to leaving these coils permanently closed is that they are really secondary transformer windings and would demand unduly large primary currents in the other coils. A case, however, in which such short circuits are tolerated, is in the present self-starting fan motors. The principle is further and lucidly illustrated by reference to Fig. 71. Here various copper bands are represented as embracing the pole tip, and successively lagging currents will be induced in them by the action of the main current winding. A shifting of the magnetism over the face of the pole will result, and this will drag the short-circuited rotor in the direction shown by the arrow. Of course the currents induced in the rotor are the ones proportional to the torque, but with these starting coils left permanently in circuit, great heat and waste results. In Fig. 72 is shown the actual form of the short-circuited sheet copper bands largely employed on four-pole fan motors. In addition to their electrical function in starting the rotation, they serve to hold the main field coils in place.

For all the shifting-field motors the simple squirrel-cage rotors are now commonly used. The construction is cheap and highly effective. One point of great importance in the mechanical design is in having a very small clearance between stationary and revolving parts. The induction motor is really a transformer, with the primary winding on the stationary and the secondary on the revolving member. All the lines of force produced by the one should cut the other, and in the regular construction of transformers this criterion is closely attained by having both coils on the same iron. With the motors, some separation of these windings is imperative, but it is made of scant amount. In machines of 100 horse-power the clearance may be only one-sixteenth of an inch; in those for about 5 horse-power, one-thirty-second, and in fan motors only one-sixty-fourth of an inch. By whatever amount lines of force produced by the primary do not cut the secondary, the self-induction of the motor is increased and the power factor reduced. This means the requirement of more amperes to produce a given power, and interference with the regulation of voltage on the circuit.

Though the multi-phase motors in themselves may leave little to be desired, their use is prevented by lack of the proper circuit. Station managers object to the complexity and expense of providing three or four wires and two or three meters for small customers, hence there is an increasing demand for efficient single-phase motors of moderate size, say from one to ten horse-power. For such purposes some manufacturers often supply ordinary three-phase machines, allowing two phases to be connected in series, as if a single circuit, and then putting a condenser or reactive-coil in connection with the other phase to enable a start to be made. This latter circuit would then be cut out. A good winding for the stator of single-phase motors can

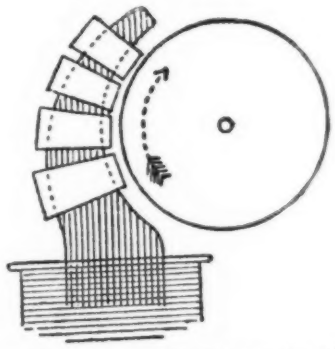


Fig. 71.—Short-Circuited Coils on Pole Tips for Giving a Shifting Field Magnetism.

be made by imitating that employed for generators. Concentric coils may be used, grouped in any desired number of poles, the iron in the centers of the groups being magnetized the strongest, and then the neighboring teeth having gradually less strength, in accordance with the requirements of a good wave form.

Fig. 73 represents the circuits of a four-pole single-phase stator and squirrel-cage rotor. At a given instant, current may be imagined as coming in the direction of arrow at top, and passing into No. 1 slot, then by the dotted line to slot No. 2, again to the front, then

into 24, return by 3, then into 23, return by 4, then into 22, and by a reach in the other direction to 17, and so on for all the slots. The large teeth in the center of top and bottom groups will then be strong "Norths," their adjoining teeth weaker, while similarly, the poles on right and left will be "Souths." With every alternation of the current these polarities will be exchanged. Upon closing the main switch to such a motor, large currents will be induced in the short-circuited rotor, demanding correspondingly large currents in the stator coils, often sufficient to blow the fuses, but there will be absolutely no tendency toward rotation. With no load connected, a vigorous start can be made, by hand, in either direction, and the rotor will continue in a rather hesitating and feeble manner, but with increasing speed there will be a gain in torque, until synchronism is approached, when the load may be applied. For a four-pole 60-cycle motor of one horse-power, 1,600 revolutions might be attained—the synchronous speed being 1,800.

Self-starting features, though with feeble torque, could be provided by making the slots deeper, or by introducing extra ones, in which additional coils, following the scheme of Fig. 70, could be placed, and the split-phase principle utilized. One coil could embrace the tooth between slots Nos. 22 and 23, then spread into slots 21 and 24, finally into 20 and 1. Similarly for the other groups of slots. This auxiliary winding would be placed in the slots, occupying not more than one-half the space; if of relatively fine wire, with three or four times as many turns as the main winding, the start could be made by connecting the two circuits in parallel, as shown in Fig. 70, but if of coarse wire of few turns, it should be short-circuited by closing a switch, giving the effect represented in Fig. 72.

It is an interesting fact to observe that fan motors cannot ordinarily be used for small powers. Such motors are designed so inefficiently that large dependence is placed upon the breeze to keep not only the person cool, but also the machine itself; when a pulley is substituted for the fan, even when motor is running free, the coils get ruinously hot.

Sometimes, as for starting heavy machinery, a single-phase motor is desired that exerts strong initial torque, and has also the high efficiency and inherent speed regulation of an induction motor. These apparently irreconcilable factors have actually been attained, the best construction being that by the Wagner Electric Company, of St. Louis. In this the stator is wound in accordance with the diagram given in Fig. 73, but the rotor has a winding and commutator as if intended for direct currents. Considerable lead is given to the brushes, to enable start to be made as a repulsion motor. Some sparking, and as in case of a series motor, no particular limit of speed is involved. However, a centrifugal governor, inside the armature, is provided, that at synchronous speed slides a ring along the shaft and short circuits all the commutator segments, and at the same time removes the brushes from contact. From this instant the motor operates on the induction principle. Though of rugged running qualities, these motors require a large starting current, and at most have a low power factor, about 0.7, but in these respects are no worse than other single-phase constructions.

For railway engineering, multi-phase motors are not all appropriate. Aside from the inconvenient and even dangerous requirement of two or three trolley wires, in addition to the use of the rails, for conductors, there is the further disadvantage that such motors imitate

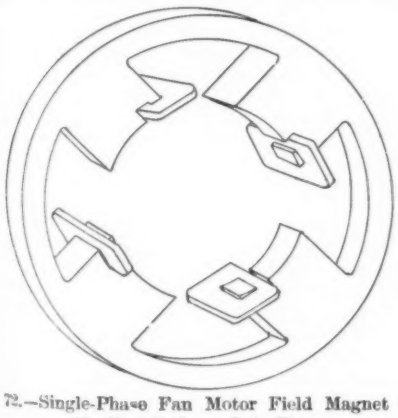


Fig. 72.—Single-Phase Fan Motor Field Magnet with Shading Coils on Pole Tips.

the characteristics of direct current shunt wound machines, i. e., are best adapted for constant speeds. As explained in Chapter IX, series wound motors are the simplest and best. It is true that in Europe a few mountain railroads, consisting of single tracks and no crossings, have been equipped with three-phase apparatus, but the results sought were simple, or regarded as merely experimental. New zest attaches to electric traction in this country by reason, as earlier indicated in this chapter, of the attempts to utilize series-wound motors on single-phase circuits. While thus utilizing the powerful starting torque and variable speed qualifications of this sort of machines, there is the other invaluable gain from the need of but one trolley wire. Further, even for the heaviest traffic, demanding large currents, there is still no need to use a "third rail," or other heavy conductor, for since the transformers can be placed on the cars or locomotives, very high potentials can be carried on the trolley wire, long distances from power stations can be tolerated, and infrequent sub-stations provided. As compared with the limitations and great expense of the common 500-volt direct-current systems, the possibilities of this alternating current system are being vigorously inquired

Fig. 73.—Diagram of Stator Winding for 4-Pole Single-Phase Motor, with Squirrel-Cage Rotor. (Not Self-Starting.)

into, and some highly encouraging results have actually been attained. Some small roads have been in operation for nearly two years, and some existing steam roads have been trying heavy locomotives equipped with motors of large size.

Among the causes that have militated against favorable operation of series motors on alternating current circuits may be mentioned, primarily, the self-induction and sparking. Of these, the former can be minimized by low frequency of alternations, few turns of conductors on the field, and special coils to neutralize the inductance of the armature. To make a completely non-inductive field winding is a contradiction of terms, for the sole purpose of that winding is to induce magnetism. Since self-induction increases directly as the frequency, a low figure, 25 cycles per second, has been adopted, with the possibility of using still lower; increasing also as the square of the number of turns, there is obvious gain in producing the required number of ampere-turns by use of large currents and few turns rather than by the opposite proportions. With the adjunct of transformers on the cars, there is the ability of getting any desired voltage. About 200 volts maximum is the potential actually employed, but instead of securing the regulation of speed by insertion of ohmic resistances, various lower voltages are impressed upon the motors, taps for the purpose being led out from the transformer windings at appropriate intervals. The "compensating" winding on pole tips provides a number of ampere-turns just equal and opposite to that of the "cross magnetizing" factor of the armature. The other troublesome defect, the sparking of brushes, has been limited by the employment of multiple-wound armatures, very narrow sections of the windings, and numerous commutator segments. Thin carbon brushes are used, bridging across not more than two segments at a time, thus short circuiting only one coil, with a further diminution of this short-circuit current by the interposition of high resistance commutator leads. Even when the armature is not rotating, but the current turned on for starting, the alternative flux of the field would induce very large short-circuit currents in the coils undergoing commutation. This is called the "transformer action" of the motor, and when rotation is taking place, this extra current flows through the brushes in addition to the main working current. With direct current motors the adoption of carbon brushes was sufficient to suppress the sparking, but further expedients were needed to cope with the new conditions.

Fig. 74 gives a diagrammatic representation of the scheme of circuits and, to some extent, the actual arrangement of the coils of a 4-pole motor of this kind. For clearness, a ring armature is shown, whereas in practice a drum would be found. The multiple character of the winding is emphasized by the four brushes and cross connections. The compensating windings consist of four sets, each being divided into three concentric coils, and set into notches in the polar faces. One of the regular field coils is also represented, being slipped in place only after these special windings are located. Both field windings and the armature are connected in a simple series circuit, but the compensating coils are arranged to have their currents under the polar faces always flowing in the opposite direction from those in the neighboring armature conductors. In the main field coils the current may flow either way, as determined by the position of the reversing switch, to give the desired direction of rotation. The high resistance feature of the commutator leads cannot well be shown in the diagram, but they are made of German silver, and looped back into the armature slots before the copper coils of the regular winding are inserted. Of course only a very few of these strips at any instant are inserted in the main circuit, as suggested in the diagram by those shown with the arrow heads.

The results attained with locomotives equipped with this type of motors, now being tried in the New Haven railroad and in the St. Clair tunnel, are being viewed with great interest, for in them the immediate future of extensive traction projects seems involved.

WOOD PAVING.

THE first attempts to pave streets with wood, three-quarters of a century ago, were failures, and for years after that no satisfactory progress was made. The blocks were round, which left large, unequal spaces between them. Their edges broke down and wore off, the wood rotted, and the pavement was soon uneven and rough, and therefore difficult to clean and unsanitary. At the present time, through the selection of suitable woods, cutting the blocks into rectangular shape so that their edges may lie close together, and treating them chemically to increase their durability, wood pavement is better in many respects than any other in common use. It is smooth, quiet, resilient, easily cleaned, and easily repaired. In wearing qualities it is superior to macadam, brick, or asphalt, and inferior only to granite and sandstone. In sanitary qualities it exceeds all but asphalt. No road surface is easier to draw a load upon, or, as it is put in technical language, none offers a lower "traction resistance," and none is easier to keep clean. Creosoted wood pavement stands above the average in smoothness, freedom from dust, mud, noise, reflection of light, radiation of heat, and ease of maintenance.

The first cost of creosoted wood is greater than that of macadam, brick, or asphalt, but not so great as granite or sandstone. On the other hand, it must be remembered, it exceeds any of the first group in wearing qualities. Too much weight is sometimes attached to the initial cost of creosoted wood and too little to its counterbalancing durability, which is equally important in calculating investment returns. It costs from $2.40 to $3.50 per square yard, laid, as compared with an average of $3.50 for sandstone, $3.26 for granite, $2.30 for asphalt, $2.06 for brick, and $0.99 for macadam, in a number of cities.

Cedar has been extensively laid in the Middle West, and oak, cypress, white pine, hemlock, western red cedar, cottonwood, mesquite, Osage orange, redwood, Douglas fir, and tamarack in various cities of the country. Untreated American red gum, tried in England, raised great hopes, but it finally proved unsatisfactory. Pavement of Australian eucalyptus has lasted for from fifteen to twenty years in the streets of London. It is more slippery, however, than American woods, and its cost, about $5 per square yard in the United States, is prohibitive.

In recent years the difficulties which attended the use of wood pavement have been largely overcome by better methods of handling, treating, and laying the

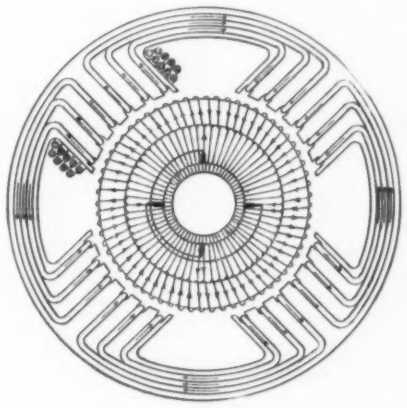


Fig. 74.—Series-Wound Motor with Compensating Coils on Pole-Tips. Railway Type.

blocks. Creosote is the best of the preservatives in common use for wood pavement. Since it is insoluble in water, it does not leach out, and if a sufficient amount is injected into the blocks it prevents the entrance of water, which weakens the pavement.

The blocks should be rectangular in shape. For heavy traffic their depth should be not less than 4 inches. The usual width is 3 or 4 inches, and the best length from 6 to 10 inches. They should be laid with the grain vertical, on a concrete foundation having a thin surface cushion of sand or other material.

THE PHOTOGRAPHY OF COLOR.—II.*

A HISTORY OF PHOTOGRAPHIC COLOR RESEARCH AND ITS PRESENT STATUS.

BY CHAPMAN JONES, F.I.C., F.C.S., ETC.

Concluded from Supplement No. 1686, page 263.

THE Young-Helmholtz theory of color vision supposes that the normal human eye is sensitive to only three fundamental colors; that is, that the points of sensitiveness of the retina, whatever they may be, are of three kinds. When white light falls upon the retina all three are excited to a definite (or equal) proportion, and when this proportion of excitation varies we become conscious of color. Granting this, it follows that if the color can be found that corresponds to each kind of sensitiveness, we shall have three colors that will, by their mixture, serve to imitate every possible color, including, of course, black and white. These three fundamental colors have been determined from time to time by various investigators, and may be roughly described as red, green, and blue. We may then, for reproduction purposes, regard the light reflected from any object whatever, when illuminated in any manner whatever, as consisting of a mixture of these three colors (or two or one of them), and by restricting the light that falls upon a sensitive plate to one of them at a time, a photograph can be made of each light-constituent reflected by the object. The photographs are themselves colorless, but they are color records, and it only remains to bring together the three colors as indicated by the photographs to produce a picture that appears of exactly the same colors as the original—because it has exactly the same effect upon the retina. In this case no color is produced by photography or by the photograph; the colors are pigments or dyes, and the photography merely locates them.

This is the principle of "three-color" processes, and, speaking practically, all indirect color photography comes under this description. It must not be thought that three-color work is dependent upon the Young-Helmholtz theory of color perception—it is founded rather upon the experimental facts that underlie that theory. The theory and three-color processes are better regarded as two independent products of the same set of facts, and these facts will remain whatever fate awaits the color-vision theory. Indeed the connection between this theory and three-color photography may not be so intimate as it appears to some to be. The colors that represent the three sensations are fairly definite, and Col. Von Hübl maintains that the number of sets of three colors that will serve for three-color work is indefinite. He arranges the spectrum tints in a circle with complementary colors diametrically opposite each other on a plan that would take too long to describe here, and states that the best three colors will be at the angles of an equilateral triangle drawn in the circle, and that the triangle may be in any position. At the same time he allows that practical considerations—chiefly the difficulty of getting a bright yellow by the mixing of pigments—obliges one to use the three colors which, if they do not exactly match the three primary sensation colors, approximate to them. Sir William Abney, who has done a great deal of work in this connection, and is a very successful producer of color photographs, accepts absolutely the Young-Helmholtz theory of color vision as his guide, and has redetermined the spectrum curves of the primary sensations. Mr. F. E. Ives, who has worked as a pioneer with very notable success in many departments of color photography, does practically the same, working according to Maxwell's curves. On the other hand it has been stated that the color screens used by various workers do not always conform to their theories. It must be borne in mind, however, that the dyes and pigments used have to be selected from those that are available, and that the best of them are only more or less close approximations to what is really sought for. Thus the theories as to the selection of the colors are more diverse than the practice.

Having obtained the red, green, and blue records, there are two distinct methods by which the colors may be combined to form the picture. Each may be caused to give its appropriate color separately, as by the use of a set of three optical lanterns, each giving one of the required colors (the photograph regulating its distribution and intensity), the three colored images being superposed on the screen. The three colors are added together, light is added to light; the combined effect of all three is white and their absence is black. In the other method the three color prints are superposed to form a single print or transparency. Here the combined effect of all three is black, their absence is white, and each color subtracts whatever it can from the light—the same light that passes through all of them. In the first case the lights are added, and in the second the absorptions. The first is sometimes called the additive method and the second the subtractive method. The colors transmitted by each of the three prints in the second method must be the complementaries of those transmitted in the first case. Taking for example a red patch in the original, this will give a transparent or depositless place on the print that represents the redness of the original, which, by the triple lantern method, would give a red patch on the screen as required. But for printing or staining purposes this holds no color, and so remains colorless. The prints that represent the greenness and the blueness of the original will be colored at this part, the former by a color that absorbs green and transmits red and blue, the latter by a color that absorbs blue and transmits red and green. Thus the only color that can get through the three superposed colored images is the red, as required. In the additive method each image contributes one of the three colors, in the subtractive method each image subtracts or absorbs one of the three colors. These are the general principles of three-color photography in its two main sections.

Three-color photography is practised commercially on a very large scale, and has been investigated and discoursed upon by a vast number of persons. A great many have dealt with the subject from a purely scientific point of view, while printers, ink-makers, and others look only at practical results. I propose therefore only to indicate the chief facts concerning its development, and to consider the most important processes that are in use at the present.

It seems that Clerk Maxwell was the first, in 1855, to suggest the principle of three-color photography, but he used it as an illustration of the functions of the three systems of nerves according to Young's theory rather than a suggestion for practical photography. He says: "Let a plate of red glass be placed before the camera and an impression taken. The positive of this will be transparent wherever the red light has been abundant in the landscape and opaque where it has been wanting. Let it now be put in a magic lantern along with the red glass, and a red picture will be thrown on the screen. Let this operation be repeated with a green and a violet glass, and by means of three magic lanterns let the three images be superposed on the screen. . . . A complete copy of the landscape, as far as visible color is concerned, will be thrown on the screen. The only apparent difference will be that the copy will be more subdued or less pure in tint than the original."

Work of this kind was very difficult because of the insensitiveness of the collodion plates then employed to green and especially to red light. It was not until 1873 that the sensitizing effect of certain dyes upon photographic plates was discovered by Prof. H. W. Vogel. Now by this means plates can be made usefully sensitive even into the infra-red. The possibilities of special sensitizing, and the introduction of gelatine dry plates about 1878, cleared away many difficulties that sorely hampered and might well have discouraged the earlier workers. From this time the development of three-color photography was a matter of perfecting details rather than evolving new principles, and devising methods for converting laboratory experiments into commercial methods.

The additive method—the three colored images being separately illuminated—was made into a really practical method by Mr. F. E. Ives, of Philadelphia. Mr. Ives first demonstrated the capabilities of the process at the Franklin Institute in Philadelphia in 1888. The apparatus that he devised for the purpose consisted of a camera for taking the three color records, a triple lantern for projecting the picture on to the screen, and the photo-chromoscope. This last is a compact apparatus containing three colored glasses, one for each color record as required, and a system of mirrors, so that the three colored images are seen superposed by looking in at the eye-piece. Shortly afterward the apparatus was made stereoscopic. The reproductions as seen in this apparatus are remarkably realistic, and I do not think that any method has surpassed them. The one drawback is that an apparatus has to be used for seeing the pictures. Mr. Ives says that he worked "in accordance with the Young-Helmholtz-Maxwell theory of color vision." "Although the three fundamental color sensations are red, green, and blue-violet, the three images of the triple photograph are not made through red, green, and blue-violet glasses, nor by the action of red, green, and blue-violet rays, but each by the joint action of all rays that have power to excite the respective fundamental color sensations, . . . according to the measurements of Maxwell and Abney." Thus the color screens used for taking the object each transmitted a large proportion of the spectrum. But for viewing or projecting the photographs Mr. Ives claimed to use color screens that transmit only a narrow band of the spectrum, just that part in each case that will best excite the one sensation, and, as far as possible, that only. The disadvantage of narrow-band color screens is that they transmit comparatively little light, and it has been stated that the screens used by Mr. Ives did not well conform to his theory. I have already referred to the uncertainty of these matters, but assuredly Mr. Ives was guided by the principles he professed, and he was remarkably successful.

The necessity for taking three separate negatives is obviously a circumstance to be avoided if possible, and the method of avoiding it was pointed out by Du Hauron in 1869. It appears that the only practicable method of making one plate suffice is to divide the surface of the plate among the three colors, using such small parts of the plate for each that when viewed in the usual way these parts merge into each other, as the fine detail of the impression of a copper or steel engraving does. The drawback to all such methods is the great loss of light. If any color is represented by only one-third the area of the patch that stands for it, the area which might otherwise be all color is two-thirds black. Thus two-thirds, more or less, of the light that would form the image in Ives's apparatus is lost in a one-plate process, and the picture is correspondingly duller unless the light is proportionately increased. This can be accomplished if the picture is in the form of a lantern slide, by using the same light in the lantern but reducing the diameter of the picture on the screen from 10 feet to 6 feet or less, or from 8 feet to something under 5 feet.

The first successful methods of this kind were worked out independently by Dr. John Joly, of Dublin, and Mr. J. W. McDonough, in America, from 1892 to about 1898. The later years of this period include attempts to make the process workable, so that the screens necessary might be manufactured in quantity, but in this they were not successful. The three colors were arranged regularly in lines, and were applied to the glass by means of a ruling pen, though other methods were tried afterward. Dr. Joly followed Ives very nearly so far as his colors were concerned, except that he sought to get his colors to accord with the more recently determined sensation curves. He used two color screens—a "taking screen" that was fixed in front of the plate while the exposure was being made, and a "viewing screen" which was put in front of the positive for seeing the picture, and might be bound up with it as a fixture if preferred. The lines were always so coarse as to be obtrusive.

Quite recently, after years of work, Mr. John H. Powrie, of Chicago, assisted by Miss Florence Warner, has so far perfected a triple-line method that he has been able to show many excellent examples. He has overcome the difficulty of making the fine colored lines by discarding ruling methods altogether. He coats the glass with a suitable colloid made sensitive with potassium bichromate, and exposes this to light under a black-line screen that has lines twice the width of the spaces between them. The light makes the colloid insoluble in warm water, so that when "developed" like a carbon print, the coating is entirely dissolved away where it was protected by the black lines of the screen, and remains on the glass in fine lines corresponding to the screen spaces. The plate is put into a solution of a green dye; the colloid absorbs the dye, and thus the green lines are formed. The colloid is made quite insoluble to fix the dye. The plate is then coated again, and treated exactly as before; but care is taken that the black lines of the screen hide the green lines already produced, and a red dye is used. It remains to get the blue lines that shall exactly fill the spaces between the two sets of lines already obtained and without any overlapping of them. The plate is coated again, and this time exposed to light without the black line screen, but with its back to the light, so that the red and green lines on the plate prevent any light effect on the coating that overlies them and acts only upon the parts between. Warm

* Abstracted from Science Progress.

water dissolves away the new colloid layer over the green and red lines, leaving it exactly filling the spaces between them. The plate is put into a solution of a blue dye to stain the new lines. By this method the lines can be made more than twice as fine as by ruling (more than 600 to the inch), and the troubles of overlapping and of uncolored gaps are entirely obviated. The method of using these plates, when they are issued to the public, will doubtless be similar to that of the Lumière "Autochrome" plates, described in another paragraph. Their special advantages will be referred to later.

It may be here mentioned in passing that during the last twelve years it has been shown by many workers to be possible to get three colors that will serve more or less well by the use of prisms or diffraction gratings instead of dyes or pigments. But these methods do not appear to lend themselves kindly to practical work, even if no exception is taken to the principles upon which they are based.

Instead of arranging the three colors in lines, they may be disposed in small hexagon or square patches. These methods have been patented, but nothing practical has yet come of the idea. The third alternative is a random grain, and a method of doing this by means of starch granules, which was described by Messrs. Lumière, of Lyons, rather more than three years ago, has just been commercially perfected. Quantities of starch granules of approximately uniform size are stained respectively red, green, and blue, mixed as thoroughly as can be in such proportions as present a neutral gray to the eye, and dusted over a prepared plate so that they adhere in a single layer, which is then pressed or dusted with a black powder (or both) to fill up the small spaces between the granules. A protective waterproof varnish is applied, and on this is spread an orthochromatic emulsion, so that the plate is complete in itself — photographic plate and color screen in one. It is exposed in the camera exactly as usual, except that the glass side of the plate is put toward the lens, so that the light has to pass through the layer of colored starch granules before it affects the sensitive film. The plate is developed, and the resulting negative, instead of being fixed, has the metallic silver that constitutes the image dissolved away, and the remaining silver salt reduced to the metallic state, thus transforming the negative into a positive. When viewed as a transparency, the color as well as the form of the original are seen. The preparation of these plates must be regarded as a triumph of manufacturing skill. Some very excellent results have been obtained with them, but the colors are readily affected by error in their treatment. The "grain" of these plates is not so fine as one might suppose from the fact that starch granules are used, for it is apparently impossible to thoroughly mix the differently colored granules. They occur on the plates in groups up to a dozen or more of one color, and the groups are visible by a magnification much too low to show the individual granules.

A one-plate process such as that just described obviously must have the same dyes for taking the photograph, that is for dividing the color of the original into the three fundamental colors, as for viewing the result, and this is a disadvantage. It is practically impossible to multiply such color photographs by exposing a new plate to light under a finished plate, because, as we have seen in the first plate, two-thirds of the light is lost, and the effect of making such a copy would be to lose two-thirds of the light passing through the first. Such a copy would, therefore, have about eight-ninths of its surface dark, reducing the light that would otherwise be available to about one-ninth, and it would be so dark as to be almost useless. Mr. Powrie has shown how it is possible to overcome the difficulty when using his plates, by fixing a mirror on each side of the printing-frame so that the light impinges on the plate from three directions, and then by suitably separating the two plates by a sheet of glass or celluloid every line in the upper plate—the picture—can be made to give a line three times its width on the lower plate. So each of the three colors in the upper plate covers the whole surface of the lower plate, and no light is lost. By using light that corresponds to one color only, it is possible by this means to get a record of that color on an ordinary plate that is continuous—that is, that covers its whole surface instead of being as the original is, in lines that cover only one-third of its surface. Three separate continuous color records, one for each color, can thus be obtained from the original single plate, and any three-color process can be worked from these records.

The subtractive method, in which the three colored prints are superposed, and each subtracts its quota from the light that passes through, was foreshadowed by Du Hauron and by Charles Cros. The production of transparencies in this way engaged the attention of Mr. Ives, and in 1893 he showed me a very fine example, perhaps 8 inches by 6 inches or larger. But it is to Mr. Sanger-Shepherd and his firm that we owe the establishment of this process, and the supply of the necessities for it, so that it can be worked by any one who wishes to do so. The usual three color records are obtained; the one from the red screen is printed on a lantern transparency plate and the image is toned to a greenish blue color, and the other two records are printed on bichromated gelatine films supported on celluloid, exposing through the celluloid. These, after development in warm water, are stained by suitable dyes, and then mounted on the greenish blue image, preferably by cementing them together with Canada balsam. One advantage of this method is that the three colored images can be tentatively placed together, and if one color is predominant a little of the dye can be washed out from that print, while if one is deficient it can be stained deeper. A somewhat similar method was introduced in 1895 by Messrs. Meister, Lucius & Brüning. Three transparencies are prepared from the ordinary three negatives, and under each of these is exposed a sheet of bichromated gelatine. These gelatine prints are washed, and each is immersed in its appropriate dye solution. The dye is absorbed where the gelatine has not been acted on by light, but where the combined action of light and the bichromate has fully affected it, it is hardened and does not absorb the dye. These are called "print plates," for their function is to give up the dyes they have absorbed to a sheet of glass coated with a soft film of gelatine, which is pressed into optical contact with each "print plate" in turn. The "print plates" can be used repeatedly. Messrs. Sanger-Shepherd have perfected a somewhat similar method for making color prints on paper, but their gelatine prints, which absorb the dye and then give it up to form the final picture, are developed in warm water and so form low reliefs. As "carbon" prints can be made in any color, some of the firms that make carbon tissues have devised methods by which three carbon prints are made of the required colors from the three color record negatives and then superposed.

As any method by which the three colored impressions can be superimposed on paper will give a three color print, various printing-press methods are available, and some exceedingly fine work has been done by collotype printing, the printing surface being of hardened gelatine and inked up with printers' inks. But the process that is of all the most advantageous, especially where many impressions are wanted, consists in the preparation of three half-tone blocks, one corresponding to each of the three color records, and making from these three superposed impressions in the three necessary colors. The greatest difficulty of these methods is in the getting of suitable inks, for they should not only be of the correct color, but they (or at least two of them) should be transparent, and they should be permanent. The most suitable coloring matters are too fugitive, so theory has to be compromised, and as none are really transparent there is always a tendency for the color last printed to predominate. In spite of these drawbacks very excellent work is done commercially by this process, but probably never without "fine etching"—that is, proof impressions from the blocks are compared critically with the original by persons who have been trained to appreciate color and drawing; and where the tints are incorrect the alterations required are marked on the impressions, and the blocks are returned to the etcher, who works on the faulty part. In the best work this proofing and correction is repeated until the result is satisfactory. The "half-tone" block prints a series of dots equidistant from their centers and larger as the tone or shadow is deeper. In superposing the three impressions no attempt is made—indeed it would be practically impossible—to print the corresponding dots exactly over each other, and the result is that sometimes the dots are superposed and sometimes juxtaposed, according to chance. This might appear to lead to a mixture of the additive and subtractive effects, and as the colors for the one method must be the complementaries of those used in the other, it might be supposed that confusion would result It is not so, however. Where only one ink is required, and where all three are required to their fullest extent to give black, the case is simple. Take the intermediate case of a gray produced by juxtaposition only of the three inks and in such a manner that the white paper is completely covered. As each ink absorbs one of the three fundamental colors, we may describe the gray roughly as one-third black and two-thirds white. If now the three colors are superposed they will produce black, but only one-third of the area of the spot of white paper concerned will be covered, so that the result will be actually one-third black and two-thirds white—practically as before.

In all the processes so far considered the color has been produced by light, or its distribution has been controlled by it. But there is a radically different method that has been in the minds of those interested in these matters for nearly thirty years, and latterly has been worked upon by many investigators with more or less, but on the whole gradually growing, success. The three necessary colors are put on the paper to begin with, and the light destroys or bleaches those that are not wanted. The method depends upon the fact that light can affect a substance only when it is absorbed, and therefore when a mixture of unstable colored substances is exposed to colored light, there is always a tendency for those substances that are of the same color as the light to survive the longest, because they reflect more of the light than the others. The difficulties in working out such a method are many. The three dyes must be of the right colors, they must be about equally bleachable by white light, they must be readily bleached or the exposure would be too prolonged, and it is desirable that they shall be rendered more stable after the exposure. Dr. J. H. Smith, of Zurich, about a year ago put this method on a commercial footing and issued the paper ready for exposure beneath the colored original under the name of "Uto" paper. The colors are made more sensitive by the addition of anethole, and after the exposure the print is soaked in benzene or acetone to remove the sensitizer. This paper gives surprisingly vivid reproductions of the color of the original, but obviously the prints are not very stable to light.

Thus the present practical methods of color photography are "three-color" methods, and they do not aim at reproducing color, but only at imitating it. If the imitation is perfect by daylight it will probably be faulty by artificial light, and a spectroscopic analysis of the two colors will at once show their differences. The perfection of the imitation depends upon the skill of the worker as well as upon the characteristics of the method. The color of the photograph is not impersonal evidence of the color of the original; but the same qualification applies to the vast majority of observation records. This much, however, may be said in favor of three-color processes—if a series of photographs is made by the same process and with the same materials, the discrepancies of color would probably be more easy to trace than the random errors possible when the coloring is done entirely by hand. Moreover, any one who is accustomed to photographic manipulations and others with practice can work some of the processes, while it must be the comparatively few who can ever hope to become skilled in applying colors with the brush.

MUD-BINDING GRASSES.

THE following notice from the Kew Bulletin bears upon the subject of some of the remarks of Lord Montagu in the discussion on Mr. A. E. Carey's paper on Coast Erosion.

The question of sea-defense work, now occupying the attention of the Royal Commission on Coast Erosion, is one of great general interest. Much has been recorded with regard to mechanical devices for arresting the removal and promoting the accretion of shingle, while the preservation and fixation of dunes by sand-binding grasses and other sand-loving plants has been dealt with so often that the subject now possesses a voluminous literature of its own. This literature has been fully summarized by Gerhardt in "Handbuch des deutschen Dünenbaues,"* pp. 629-644, Berlin, 1900, to which reference may be made by those who may desire full information on the subject.

The latest and one of the most comprehensive accounts of sand-binding grasses enumerated by Gerhardt is that by Mr. Lamson-Scribner, published in the "Year Book of the United States Department of Agriculture for 1898," pp. 405-420. A perusal of this paper may be recommended to all who desire to find the salient facts clearly presented in a concise manner.

As compared with the effects of vegetation in preserving sandy shores and fixing sandy foreshores, the action of plants in assisting the accretion of mud and in fixing and preserving muddy foreshores has received comparatively little systematic attention. A sketch of these processes as they present themselves in the great Gangetic delta has been given in the "Records of the Botanical Survey of India," vol. ii, No. 4, pp. 231 et seq.† and incidental allusions to the subject are to be found scattered throughout the literature of topographical and geological botany. The subject is, however, one that is of much interest everywhere from the purely scientific point of view, and one that even in this country may be of considerable practical importance.

Giving evidence before the Royal Commission on Coast Erosion, Lord Montagu of Beaulieu is reported as follows: "The mud banks on his property had gradually been increasing very rapidly. The accretion was due to a somewhat extraordinary fact. Some years ago a ship came up Southampton Water from the River Plate with a quantity of rice grass on board. The seeds of this grass became distributed about the shores of Southampton Water, with the result that the whole of that estuary was now covered with this grass. It was a plant which grew very rapidly and spread in circles, and now the twenty miles from Hurst Castle

* Handbuch des deutschen Dünenbaues im Auftrage des Kgl. Preuss. Ministerium der öffentlichen Arbeiten und unter Mitwirkung von Dr. Johannes Abromeit, Paul Bock, Dr. Alfred Jentzsch, herausgegeben von Paul Gerhardt; Berlin, 1900, pp. i.-xxviii., 1-656, with 445 figures in the text.

† See especially a reference to the action of *Oryza coarctata*, Roxb., at p. 357.

to Southampton were covered with this grass, as were the mud banks on his foreshore. The stiff and sharp points caught the seaweed which came over it, causing the bank to increase rapidly in height. . . . There was no knowledge of the grass, so far as he could understand, up to ten years ago."

To anyone knowing the vegetation of the coast of Southampton Water, it was evident that the grass in question must be a member of the genus *Spartina*, though the names "rice-grass" and "sea-rice" are unknown in botanical literature, and also to those most versed in the popular names of British plants.

THE FIRST WEATHER PLANT OBSERVATORY.

A NOVEL ENGLISH EXPERIMENT.

BY HAROLD J. SHEPSTONE.

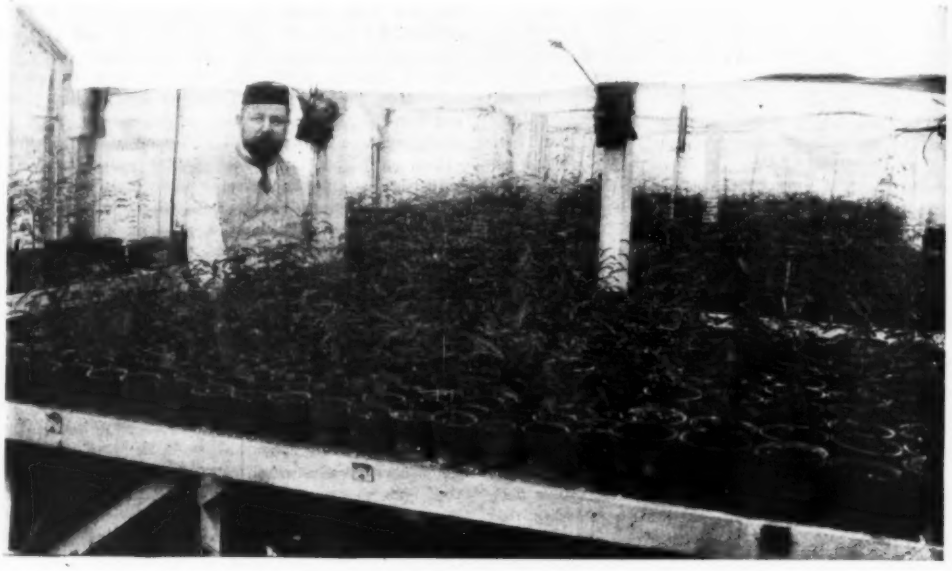
THERE will shortly be opened in London what it is hoped will be the first of a series of stations for the forecasting of natural phenomena and the weather on land and sea largely by means of a common tropical plant. It is believed that by means of this plant, in conjunction with other data, it is possible to predict with certainty forthcoming disturbances in the form of storms, cyclones, earthquakes, fire-damps, volcanic eruptions, etc.

This new method of predicting weather conditions is due to Prof. J. F. Nowack, an Austrian baron. The system is primarily based upon his discovery of a tropical plant, *Abrus precatorius nobilis*, commonly called the "weather plant"; secondly, upon data obtained from studies of sun-spots; thirdly, upon statistics continuously recorded of natural phenomena occurring throughout the world; and fourthly, upon general studies in physics, geology, chemistry, and botany.

After continuous observations, day and night, and cultivation under special conditions, he has discovered that the weather plant becomes so sensitive to electric and magnetic influences—a susceptibility fitly comparable with that of the compass needle toward the magnetic poles—that immediately changes in the distribution of the electric and magnetic forces of our atmosphere and earth respectively occur, the twigs and leaves of the plant perform peculiar and abnormal movements, each of which has its definite significance.

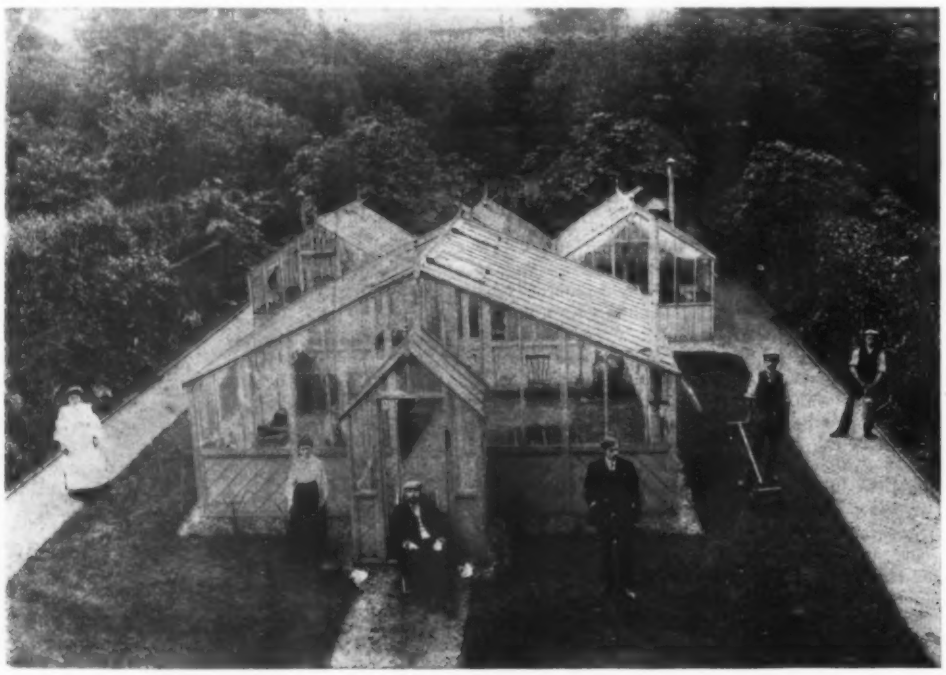
For instance, immediately a spot sufficiently large to influence our earth appears on the surface of the sun, the twigs directed toward the district affected perform more or less rapid upward or downward movements. From the rapidity and extent of such movements, the direction in which the twigs point, as also their variation of color, can at once be determined the nature, force, and geographical position of the disturbances that will affect our earth about twenty-six days later, i. e., when the spot completes its first rotation round the sun.

Public attention was first drawn to Prof. Nowack's discovery and researches during the Vienna Jubilee Exhibition in 1888, when some specimens of the weather plant were exhibited, and weather forecasts were given forty-eight hours in advance, not only for the whole day, but for special hours of the day. These hourly forecasts proved sufficiently correct to attract general attention; they were extensively noticed by the Austrian and German press, and the discovery was recognized by many leading men of science. His Majesty the Emperor Francis Joseph presented the discoverer with a diamond scarf-pin. At the invitation of King Edward VII., then Prince of Wales, Prof. Nowack was invited to England, and for a short time studied this wonderful little plant in a special greenhouse at Kew Gardens, where he also predicted several disasters, among them being the fire-damp explosion in Staffordshire in the year 1889, in which seventy lives were lost.



PROF. NOWACK IN ONE OF HIS LONDON GREENHOUSES.

Since then Prof. Nowack has by continuous study perfected and proved his system. Last year he visited Cuba and collected 2,400 of these remarkable plants from their native soil, as well as studied them at home. He also made long journeys in Mexico, but failed to discover the plant in that country. He was in Cuba, in the neighborhood of Havana, just over three months. After the plants had been collected, they were sent to New York. Here 1,000 of them were deposited in the New York Botanical Gardens, where Mr. Pierpont Morgan has taken a personal interest in the matter. The remaining 1,400 plants were shipped to Europe, and in spite of the facts that specially heated accommodation was provided for them on board the steamer, and that an experienced gardener and a qualified assistant were told off to tend them, and that on their arrival in London they were at once deposited in a warm greenhouse, they have all, with the exception of a single plant, succumbed. The cost of collecting this one plant virtually represented an outlay of $5,000.



THE GREENHOUSES AT THE LONDON WEATHER PLANT OBSERVATORY.

THE FIRST WEATHER PLANT OBSERVATORY.

But if the plants themselves were not a success, the seeds obtained by the party have sprouted, and in the greenhouse of the London station, which is situated in the residential quarter of Denmark Hill, may be seen 1,800 weather plants all growing in Cuban soil, a large quantity of which was brought home by the expedition. It has been discovered, however, that the Indian variety of the Abrus is really more sensitive than the Cuban, and consequently more reliable for observation purposes.

The plants are accommodated in three houses, each measuring about 30 feet by 15 feet. Special stoves have been installed to maintain a temperature of 85 deg. day and night. It was found that the usual system of hot-water pipes for heating greenhouses was unsuitable, there being a certain amount of electricity in the pipes, which affected the plants. The three glass-houses will be used for distinct purposes. The first is to be reserved for the observation of the movements of the plants; the second will be where the plants will undergo preparation before they are admitted to No. 1 house; while the last is the nursery for seedlings.

All the plants are very young, only a few months old, in fact; few of them contain more than from ten to fifteen leaves. Until the plants are more developed and bear from 150 to 200 leaves apiece, practical observations will not be undertaken. It takes about two years for the plant to attain to this desired state in its native home, but by forcing it is hoped that the plants will be ready for weather forecasting during the coming autumn. Curiously enough, the plants are more active at night than during the day. The most active period is generally between the hours of three and four in the morning. The plant is highly susceptible to the presence of people, and for that reason never more than three persons are allowed to enter the greenhouses at a time.

There is nothing particularly interesting in the plant itself. It bears no flower, and consists merely of a long stalk from which branch a number of twigs containing a row of delicate-looking leaves resembling those of a maidenhair fern. But its behavior is very noticeable when pointed out to the visitor. The writer visited the greenhouses at Denmark Hill one afternoon at 3, 4, 5, and 6 o'clock respectively. During this period the various changes in the plants were decidedly

marked. In some instances the leaves had slightly changed color, while the twigs had bent themselves into curious positions, and in others the leaves had entirely closed.

Of the one thousand plants left in New York, advices received report that some 180 of them are living and doing well. Prof. Nowack handed the writer a photo-

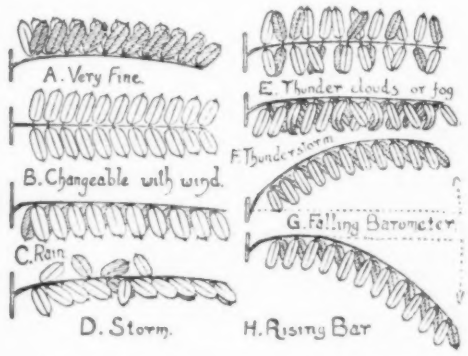
WEATHER PLANTS FROM CUBA, JAMAICA, MAURITIUS AND INDIA.

TWO OF THE WEATHER PLANTS WHICH SURVIVED IN NEW YORK.

graph of two of them which he had then just received. The principal object of leaving this consignment of weather plants in New York was with the hope of eventually opening a station there. Indeed, the professor intends, if possible, to cross the Atlantic and make arrangements for this in September next. Meanwhile he is working hard getting the London station in order.

Many may wonder why this system of forecasting has not been adopted before. It has all been a question of funds. It was only last year, through the generosity of two Austrian noblemen and a grant from the Austrian government, that Prof. Nowack is now able to open a station in London. He had previously, however, been approached by the Austrian, French, German, and Russian governments; from the Sultan of Turkey, from Lloyd's Insurance, and other great companies for the exclusive control of his system, but he rigidly refused these offers, his intention being that all mankind should benefit by it, and not a single company or individual government.

One could quote many instances of remarkable and accurate forecasts which the professor has made through the medium of his system. So far back as 1892 he deposited with the leading British societies a copy of a chart, compiled the year before, in which predictions were set forth of all violent atmospheric and seismic disturbances until 1918. Up to the present all these predictions have been fulfilled, including the earthquakes in Japan and in India, the catastrophes of Martinique, San Francisco, and Jamaica.



LEAVES OF THE WEATHER PLANT, SHOWING SENSITIVENESS TO VARYING ATMOSPHERIC CONDITIONS.

The facts surrounding the prediction of the recent disaster in Jamaica are particularly interesting. A copy of this singular chart was exhibited at his lectures on the Continent, in England, and also in Havana, where, early in 1906, before the Academy of Sciences and other scientific societies, Prof. Nowack made the startling prediction that a catastrophe would occur in Jamaica in a very short time, and which would be followed by one in Havana.

Havana, he has discovered, is situated on a submerged volcanic crater, and that it is also the crossing point of two directions in which the island will be split by the disturbance to come. The latter is set forth in the chart already mentioned, together with a further prognostication that in 1918 Colombia is to suffer a terrible catastrophe. As the forecast has so far been unquestionably accurate, it is a fair assumption that the predictions for the future will be fulfilled.

At his station in London Prof. Nowack receives newspaper cuttings from all the world's papers relating to local meteorological and seismic disturbances. These he notes on a series of charts, and the accumulated data aid him in drawing certain conclusions. He himself has kept such records for twenty years, and his office in Vienna has traced records back to the time of Christ. From these records of critical natural phenomena occurring throughout the world, the professor has found that such phenomena are restricted to eight zones encircling our earth in various directions, and that the greatest destructive atmospheric and seismic disturbances occur where such zones intersect. These zones move periodically, away from and toward each other, returning to their original positions about every thirty-five years. Hence the professor claims to predict these phenomena thirty-five years in advance.

Naturally, the principal value of a weather station is its forecast of the weather rather than of great disturbances coming in the future. Prof. Nowack claims that by his system it is possible for a single station, say in London, for a radius of about 3,000 miles (i. e., from the east coast of North America to the Ural mountains, including the Mediterranean Sea and the North of Africa):

I. To issue 24 to 28 days in advance, special charts showing the "critical" barometrical centers, as also the atmospheric and seismic disturbances, and symptoms of fire-damp explosions that may result therefrom.

II. To issue daily a general chart showing the various positions and movements of the critical barometrical centers during the succeeding 28 days.

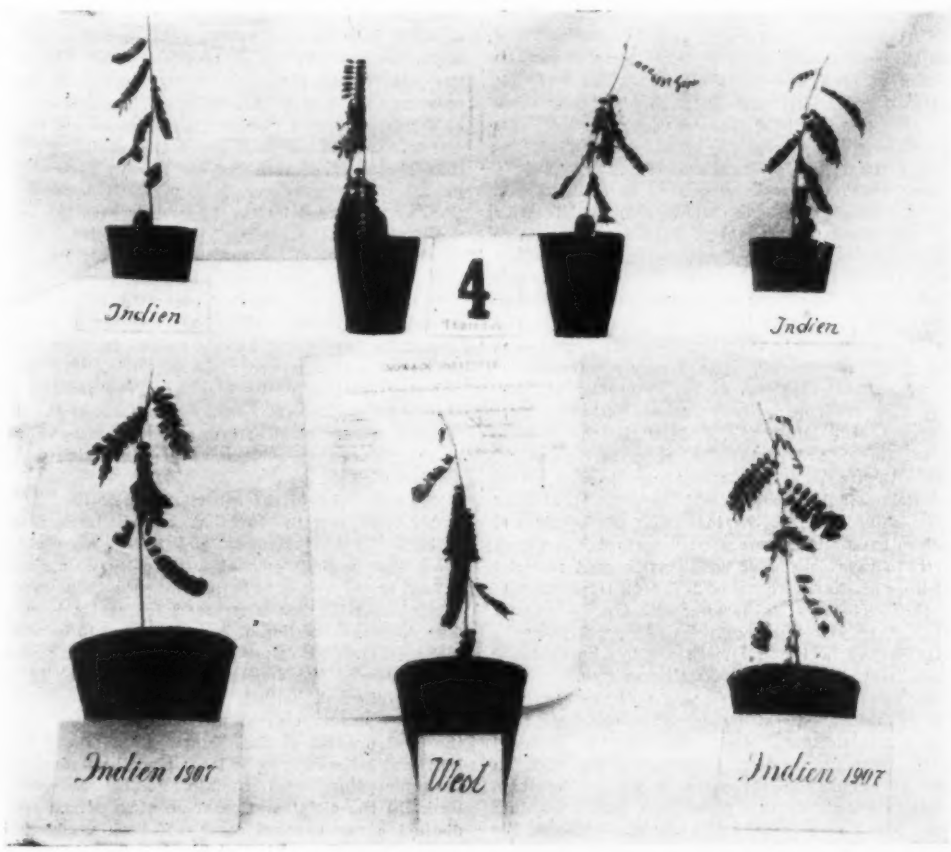
III. To issue daily a chart showing 2 to 7 days in advance isobars (lines of equal barometrical pressure).

IV. To issue daily a weather chart showing 2 to 7 days in advance the districts of rainy, fine, and foggy weather generally.

V. To publish daily a detailed forecast, showing 48 to 72 hours in advance the weather within a radius of 40 to 60 miles.

By the establishment of stations in other parts of the world, the whole earth could be included. For this reason Prof. Nowack is anxious to found a station in New York, to be followed by one in San Francisco, in Bombay, and in Tokio. These five stations would cover the whole of the northern hemisphere. In a like manner the southern hemisphere could be dealt with by another five stations.

In a paper read before the Academie des Sciences, M. Raphael Dubois gives an account of some curious phenomena which he observed. In carrying out his experiments on the role of pigments in marine animals and vegetables, he remarked a phenomenon of a purely physical order which seemed worthy of notice. When we place test tubes containing colored solutions in sea water, after exposure to the sun for forty-five minutes or more, we observe gas bubbles deposited on the outer surfaces of the tubes, and they remain there for a long time, being strongly adherent. This phenomenon is also produced in soft water. What is most striking, however, is that the tubes which contain the green solutions are covered with fine gas bubbles more quickly and in greater abundance than the others. On the outer surface and even on the inner side of the green tubes, the bubbles were so numerous that they touched each other and there resulted a disengagement of gas somewhat like that which occurs at the surface of green seaweed placed in water and exposed to the sun. In a tank of water are placed test tubes of the same size and at equal distances containing solutions colored red, yellow, green, blue. The green solution was first the chlorophyl of sea weed dissolved in alcohol, and again a chloride of nickel solution. The other tubes were colored by various soluble pigments. All the tubes were placed in sunlight which came through the plane glass side of the



YOUNG PLANTS FROM INDIA. IT IS EXPECTED THAT THE INDIAN PLANTS WILL PROVE MORE SENSITIVE THAN THOSE FROM CUBA.

THE FIRST WEATHER PLANT OBSERVATORY.

tank. The temperature of the tank was from 50 to 65 deg. F. It was then found that the bubbles upon the green tube were much more numerous than on the next tube containing the yellow solution. At the surface of the red tube there were seen but two bubbles. On the blue, there were more than upon the red and yellow, but they were distributed over all the surface and were of larger size. Owing to the composition of the gases dissolved in water, the bubbles were necessarily rich in oxygen. This phenomenon of localization upon the green tubes seems to be due to an elective absorption of heat rays.

INTERRELATIONS OF THE ELEMENTS.*

A SUMMARY OF RECENT RADIOACTIVE INVESTIGATIONS.

BY HERBERT N. M'COY, UNIVERSITY OF CHICAGO.

BEFORE the close of the eighteenth century, attempts at transmutation were recognized as futile, and one thing appeared certain, even at that time: the elements were not to be disintegrated or altered by such chemical processes as those which served to decompose their compounds.

During the past eleven years enormous advances have been made along entirely new lines, in the knowledge of the interrelations of the elements and the nature of matter. This new knowledge had its origin in the discovery by Becquerel, in 1896, of the radiations emitted by uranium. It was found by Becquerel that all uranium compounds send out rays capable of affecting a photographic plate through light-proof paper, and also of enormously increasing the electrical conductivity of air, by ionizing it. Schmidt, and independently Mme. Curie, found that all compounds of thorium produce similar rays. Scientists will never forget the intense interest taken in the discovery by the Curies of radium, a substance which possessed the properties of uranium and of thorium augmented more than a million fold. There were also new properties; powerful physiological effects, evolution of light and even of heat, it having been found by Curie and Laborde that the temperature of a tube of radium is always perceptibly above that of its surroundings. Here then was a most marvelous result—the continuous and seemingly undiminished production of energy by a portion of matter, which appeared to suffer no chemical change. It even seemed as if a source of perpetual motion had been found.

It was soon clearly established that the activity of radioactive substances was not due to the excitation of any *known* radiation. Some scientists, however, including Lord Kelvin, Becquerel, and the Curies, imagined as the source of the observed energy an unknown cosmic radiation, which was intercepted and transformed by the radioactive body, the elevation of temperature of radium above its surroundings being, according to Kelvin, analogous to that of a piece of black paper in a bottle exposed to sunlight.

The solution of the mystery of radium is largely due to Rutherford and his colleagues. There were two main problems: (1) The nature of the radiations, and (2) the nature and cause of radioactivity. The radiations were found to be of three sorts, called the α, β, and γ rays. The nature of the β rays was first established. The photo-activity is chiefly due to these rays; they readily penetrate light-proof paper; are easily deflected by a magnetic or an electric field, and in such a direction as to show that they are negatively charged. In this respect, as well as in many others, the β rays closely resemble cathode rays, which latter have been shown to consist of particles of negative electricity, called corpuscles. These corpuscles, which are shot out from the cathode with 1/10 of the velocity of light, have inertia, due to the moving electric charge; and having inertia, they have mass. The mass of a corpuscle is very small—about 1/1000 that of an atom of hydrogen. The β rays seem to differ from the cathode rays only in having greater velocity. The γ rays are apparently very penetrating X-rays; and just as the latter are produced by the cathode rays, the former are produced by the β rays.

The α rays are quite different: they are unable to penetrate a single sheet of writing paper; but they are the chief cause of the ionization of the air and the elevation of temperature. Rutherford has shown that the α rays consist of positively-charged material particles each having a mass 2 (or 4) times that of an atom of hydrogen and moving with 1/3 the velocity of light. It was now readily understood that the kinetic energy of the rays was the proximate cause of the observed evolution of heat by radium.

The counterpart of the phenomena of the rays was found in the change which occurred at the same time in the active substance itself. Crookes had observed that by treating uranium nitrate solution with an excess of ammonium carbonate, a minute insoluble precipitate remained; this precipitate, called uranium X, was found to possess practically the whole of the photo-activity of the uranium from which it had been separated. Rutherford and Soddy precipitated thorium with ammonia, and obtained from the filtrate a trifling residue called thorium X, which possessed a large share of the original activity. The activity of the thorium X decreased gradually with time; in four days the activity was reduced to $\frac{1}{2}$, in eight days to $\frac{1}{4}$. The loss of activity occurred according to the exponential law, or, as the physical chemist would say, the change was that of a first-order reaction: in each unit of time a fixed fraction of the remaining activity disappeared. To some scientists it did not appear remarkable that the radioactive principle of uranium or thorium could be separated by a chemical process; in fact, the original activity of these elements was "explained" as due to the presence of these highly active "impurities." Nor did the loss of activity by UX or ThX, considered by itself, seem extraordinary; it might be likened to loss of temperature by a cooling body.

But a most extraordinary thing was discovered by Rutherford and Soddy, in the further study of this same thorium experiment. The thorium from which ThX had been removed had, at first, only about 1/3 of its original activity; but in just that measure in which the separated ThX lost its activity, that of the thorium itself returned; until, after a period of several weeks, the thorium had entirely regained its original activity, while the ThX had become inactive. A repetition of the treatment with ammonia now yielded a new portion of ThX equal in amount to that first extracted. The behavior of UX was similar. Rutherford and Soddy then announced their now celebrated Disintegration Hypothesis: the radioactive atom is a complex system, made up of corpuscles and α particles, in rapid orbital motion; of such systems some, in the course of time, become unstable and disintegrate; the corpuscles and α particles resulting from such atomic disintegrations constitute the rays, the kinetic energy of which existed previously in the atom. The residual portion of the atom after the escape of a corpuscle or an α particle constituted an atom of a new substance (e. g. ThX), which atom might have even less stability than the original.

In all, over 20 distinct radioactive substances are now known. These constitute three series, in each of which each member produces, by its radioactive disintegration, the following member. The evidence in the case of each change is just as clear as in that of thorium and thorium X. One case in particular, that of the formation of radium from uranium, is of especial interest. It has been shown in two different ways that radium and uranium are always associated in minerals, and, moreover, in a perfectly fixed proportion, as demanded by the hypothesis that the one is the product of the other. Further, uranium minerals freed from radium by chemical processes slowly but surely reproduce the latter substance.

The chemical and physical properties of radium and its salts clearly show it to be a member of the alkaline earth family; its atomic weight is, according to the latest determination of Mme. Curie, 226.5, assuming the elements to be bivalent. The formation of radium by uranium was then a clear case of the transmutation of one element into another, whatever might be thought of such changes as that involving the production of ThX.

The properties of the α particle led Rutherford and Soddy to suggest, in 1902, that it might be an atom of helium. In 1903 Ramsay and Soddy were able to show that radium emanation actually does produce helium in the course of its spontaneous disintegration; this observation has since then frequently been confirmed. The formation of helium seemed to be another real transmutation, since the element radium undoubtedly produced the emanation which yielded in turn another element, helium.

If now uranium gives ultimately radium, what is the final product of the disintegration of the latter? Boltwood believes it to be lead; since he finds that all uranium-radium ores contain notable amounts of lead. In the disintegration of an atom of radium five distinct α ray changes occur. If each produces one α particle, with atomic weight of 4, the final product of radium should have an atomic weight of $226.5 - 20 = 206.5$, whereas the atomic weight of lead is 206.9.

There is now no shadow of doubt that the rate of radioactive change is entirely independent of the form of chemical combination of a radioactive substance; temperature is also without influence; a given transformation occurs at precisely the same rate at the temperature of liquid hydrogen and at a white heat. It thus appears that radioactive change is a natural process which is entirely beyond man's control, and important as is the establishment of this fact, the discovery falls far short of being a complete solution of the problem of the transmutation of the elements.

A further step in this direction seems to have been taken within the past few months, however, by Sir William Ramsay. The alchemist, in his attempts to alter the elements, could apply only the forces of moderate heat and chemical affinity. The chemist of the nineteenth century could command enormously greater ranges of temperature as well as powerful electrical forces; all these means were likewise without avail. And now Ramsay has tried a new force, that of radioactive radiations—corpuscles and particles of matter, both electrically charged, projected with almost inconceivable velocity. The results of the experiments of Ramsay and Cameron may be stated very briefly: Radium emanation acting on water produces neon; while with a solution of copper nitrate it produces argon; and even the copper itself appeared to be attacked, for when the latter element was removed by means of hydrogen sulphide, the filtrate was found to contain lithium. A blank experiment, in which the radium emanation was omitted, but all other conditions remained precisely the same, yielded no trace of lithium. The formation of lithium from copper has been observed four times by Ramsay, and though, as he writes in a private communication, "he was loth to believe," yet he "had to chronicle the results after four repetitions." The importance of these facts, provided they are not due to some spurious cause, needs no comment. In this connection it occurred to me that radium emanation or in general radioactive radiations might act on copper in the solid state; if so, uranium-radium minerals which contain copper should contain lithium also. For another purpose I had, more than a year earlier, separated a sample of pitchblende into its principal constituents. There was a considerable quantity of copper; there was also a solution which could contain only alkali and ammonium salts. It was but the work of an hour to examine this solution for lithium: in the spectrum the characteristic red line of lithium was next in brilliancy to that of sodium. Later, from one to two grammes of four other uranium minerals, including samples of pitchblende, carnotite, and gummite, from widely separated locailties, were examined for copper and lithium; all contained lithium, and all but one contained copper. The presence of lithium in a mineral free from copper may be explained upon the supposition that the transmutation of the latter metal had been completed.

The view that the atom is a complex system made up of negatively-charged corpuscles and positively-charged α particles has been made the subject of extensive mathematical studies by J. J. Thomson. Thomson's hypothetical atom is a system composed of rings or shells of corpuscles in a uniform sphere of positive electrification. The electro-positive or negative nature of atoms, their chemical affinity as well as their dual valence toward hydrogen and oxygen, are all most beautifully and at the same time simply explained by the behavior of such imaginary systems, the properties of which vary periodically with increasing number of corpuscles and so fulfill another indispensable requirement of any hypothetical atom. Numerous other properties of matter also receive a satisfactory explanation in terms of the new hypothesis: among such are the conductivity of metals for heat and electricity, bright line spectra, and the Zeeman effect. That the corpuscular theory is the last word on the nature of matter, none will contend. Thomson himself writes: "The theory is not an ultimate one; its object is physical rather than metaphysical. From the point of view of the physicist, a theory of matter is a policy rather than a creed; its object is to connect and co-ordinate apparently diverse phenomena, and above all to suggest, stimulate, and direct experiment."

* Read at Chicago meeting of the American Chemical Society. Reprinted (abridged) from Jour. Amer. Chem. Soc., March, 1908.

The view just given of the nature of the atom accounts also for its radioactivity. A system of revolving corpuscles of negative electricity would slowly radiate energy, at an almost infinitesimal rate, it is true; but the final result would be to produce in the system a condition of instability which would cause its partial disintegration and rearrangement. Is, then, all matter undergoing evolution? That is the question which cannot be positively answered at present. And yet there is much evidence that many elements are faintly radioactive. Such activity may be either intrinsic or due to minute amounts of known highly active substances.

Radioactive matter is easily extracted from the air by means of a negatively-charged wire exposed out of doors, as first shown in 1901 by Elster and Geitel. The rate of change of this active matter indicates that it is chiefly the excited activity, Ra A, B, and C, resulting from the disintegration of radium emanation. A simple experiment which I recently tried shows the correctness of this view. Air was liquefied, and about a liter of the liquid was allowed to evaporate, and the last portion was examined for radioactive emanations. A considerable activity was found, the rate of change of which plainly indicated the presence of radium emanation together with small amounts of other active matter. The excited activity, which is deposited everywhere by the radium emanation contained in the air, is certainly the cause of a portion of the observed activity of common things. Nevertheless, at least one common element, potassium, seems from the studies of Campbell to possess slight intrinsic activity.

On the other hand it is found that α particles having less than a certain minimum velocity are unable to produce ionization of the air. It is therefore quite possible that some atomic transformations may occur which do not show radioactive phenomena, the initial velocity of the α rays being, in such cases, below the minimum. Such change might occur at rates far greater than that of uranium and still be impossible of detection in the course of a life time by gravimetric or even probably by spectroscopic methods; since in the case of uranium the rate of change is so slow that no more 0.001 per cent disintegrates in 10,000 years; and yet the ionization method of recognizing α radiations is so surpassingly delicate that one may detect with certainty the activity due to a single milligramme of uranium in any form of combination.

In conclusion it may be said that while the work of the 19th century produced abundant and varied evidence that between the elements there exists the most intimate interrelations, the researches of the past few years of this new century have shown the fundamental significance of these relationships and lead us to the conclusion that the elements may no longer be considered immutable; that matter is probably of but a single sort, of which our commonest elements represent the more stable forms, which have resulted from a process of natural evolution.

THE PRODUCTION OF SMOKE.*

WITH SUGGESTIONS AS TO ITS PREVENTION.

BY D. T. RANDALL.

THE term smoke as used in this paper refers to chimney gases that contain small particles of unconsumed carbon, which give the gases a dark color. Smoke may be of any degree of blackness, but what some persons would call smoke is not considered smoke by others.

Smoke is due to a lack of air at the proper temperature at the point where the volatile gases should be burned, the result being that these gases are only partly burned and the carbon is set free. The density of smoke is measured in many ways, but the most satisfactory at present is by means of the Ringelmann charts. These charts are made by drawing black lines at right angles on a white background. The lines are so spaced as to give the effect of different percentages of blackness when placed at a distance of about 50 feet from the observer. The charts are numbered 1, 2, 3, 4, and 5, and represent, respectively, 20, 40, 60, 80, and 100 per cent of black smoke. As a matter of fact, anything but a clean stack will result in a smoky atmosphere. If a stack continuously emits a small amount of smoke, it may, during the course of the day, have given off as much carbon and have had as bad an effect as another stack which has been clear most of the time, but which for three or four periods of five minutes each has emitted a dense black smoke. In localities where bituminous coal is burned exclusively a plant is considered good if the average blackness is equivalent to 5 per cent or less.

The following information, taken from the report of the committee for testing smoke-preventing appliances, Manchester, England, is of interest:

"Observations were made for an entire day on 179 chimneys. The general averages of these stacks gave the equivalent of black smoke 102 minutes in 10 hours. The averages for the individual stack varied from the equivalent of black smoke for 423 minutes in the worst to 4 minutes in the best. The relative amount of the smoke from different kinds of equipment may be taken as follows:

"Average of 36 hand fires with air admission, 81 minutes in 10 hours; average of 10 hand fires with air admission, good firing, 40 minutes; average of 4 sprinkling stokers, about 103 minutes in 10 hours; average of 21 coking stokers, about 16 minutes in 10 hours; best coking stokers, about 4 minutes in 10 hours.

"Coking stokers show best economy as well as prevention of smoke.

"Sheffield Association suggest that the permissible limit of smoke emission should vary with the number of boilers as follows: For 1 boiler, 2 minutes per hour; for 2 boilers, 3 minutes per hour; for 3 or more boilers, 4 minutes per hour."

The following are reasons why furnaces sometimes smoke:

1. The furnaces and the grates are not properly designed to burn the coal available. There is almost no equipment on the market that will handle equally well all the fuels found in the United States.
2. There is a lack of sufficient draft.
3. The firemen are unskilled.
4. There is not enough combustion space.
5. Wood, paper, and other refuse are burned.
6. The load is changed quickly.
7. Excessive overloads are maintained.

Within the last few years there has been a remarkable development in the utilization of coal under the steam boiler. To-day many steam power plants in the United States are burning bituminous coal practically without smoke. This has been brought about by improving the design of the furnaces and by careful attention on the part of the fireman.

It is now possible to design and operate boiler plants burning a high-volatile coal which will be practically smokeless under usual operating conditions, giving off no black or dense gray smoke except when a fresh fire is being built. Banking the fire, shutting dampers, etc., causes smoke of a light or gray shade only. This has been demonstrated at the engineering experiment station of the University of Illinois, where a boiler has recently been installed, properly equipped with a furnace for burning Illinois coal. Under ordinary conditions this plant makes no smoke whatever. This equipment is not suitable for burning low-volatile coals such as are largely used in the East. In experimenting with this furnace an effort was made to produce smoke, but it was found impossible to make black smoke, the worst being about 50 per cent black.

A number of large commercial plants having properly designed furnaces are now operating daily without smoke in many of our larger cities.

Coal can be burned smokelessly, the same as gas, gasoline, or kerosene oil, if the equipment is properly designed and adjusted. Each of these fuels will give off smoke if conditions are not favorable. All the authorities on the subject of combustion and smoke prevention agree upon the following conditions as requirements for a smokeless furnace:

1. The coal should be supplied to the furnace in small quantities at frequent intervals. The more nearly the feed approaches a continuous and uniform supply the better the results.
2. The air supply should be slightly in excess of the theoretical amount required and be admitted principally through the fuel bed, with an auxiliary supply admitted at the front or rear of the furnace to burn gases from the coal.
3. The temperature in the furnace should be sufficiently high to ignite the gases given off from the fuel bed.
4. There should be a fire-brick combustion chamber of sufficient dimensions and so designed as to cause the thorough mixture of the gases and air, permitting complete combustion before the mixture reaches the boiler surfaces.

It has been found in this country, as well as in Europe, that when smoke is given off, there is also a loss of carbon monoxide (CO) and other combustible gases. The loss due to the carbon which we see and call smoke is seldom more than 1 per cent, but the loss due to the escape of the combustible gases may amount to an additional 3 to 10 per cent.

Contrary to general opinion, with extremely high temperatures more smoke is produced and more unburned gases are lost up the stack. High temperature is of course due to a supply of air approaching the theoretical amount, and on account of the difficulty of obtaining a complete mixture of the gases and air some gas is allowed to escape unburned.

The combustible gas most frequently found in the flue gases is carbon monoxide (CO). This gas is nearly always present when the stack gives off black smoke, indicating imperfect combustion. Hydrogen and hydrocarbon gases may also be expected in connection with the CO, but on account of the difficulty of determining the small percentages of these gases they are seldom recorded, though the loss due to their escape is considerable.

Numerous inventions for preventing smoke have been made. Most of them have not been properly designed to meet the severe service to which a boiler furnace is subjected.

The proper design of the furnace and settings, including the breeching and stacks, is a subject of much dispute. All authorities, however, agree that sufficient air must be admitted to allow complete combustion. This means that ample draft must be provided. Stacks less than 125 feet high are usually unsatisfactory, but steam or electrically driven fans are now very commonly used to produce either forced or induced draft in connection with stacks shorter than would otherwise be required.

Provision should be made for the admission of air above the fuel bed. It is also now generally conceded that there should be a fire-brick chamber of sufficient length to allow time for the gases and air to mix and burn. Numerous observations made on power plants show that it takes an average of twelve seconds for the gases to pass from the furnace to the top of a stack 125 feet high. This allows but one second for combustion to take place before the gases leave the combustion chamber. These conditions have been so successfully met in some plants as to permit the use of low-grade coal without the production of objectionable smoke. These plants are few when compared to the total number in operation, but they indicate the possibilities of securing practically perfect combustion.

DIFFICULTY IN SECURING PERFECT COMBUSTION.

With so great a variety of furnaces it seems at first thought that there should be no difficulty in abating smoke. It is, however, difficult to construct a furnace that will be smokeless under any and all conditions of operation. Some furnaces now in operation are practically so, conforming to every requirement outlined for smokeless combustion, but there is no type of grate or stoker on the market to-day which does not give off offensive black smoke in some of the plants in which it is installed. This may or may not be due to faults in the furnace. It may be due to lack of combustion space or to improper handling.

The efficiency of the furnace and the degree of success attained by any equipment in the prevention of smoke depend on the following factors: Skill of the fireman, proper design of the furnace and boiler setting, character of the coal, capacity of the boilers and furnaces, and load carried.

* Abstract from a Bulletin issued by the United States Geological Survey.

Gallisizing.—A process discovered by Ludwig Gall, by means of which, from sour must, by the fermentation with it of glucose or grape sugar and water, a drinkable wine may be obtained. The amount of sugar and acid in the must to be improved should first be determined and then the dilution and the addition of sugar calculated, according to a normal must. For instance, supposing a must to have a volume of acidity of 1.2 per cent and sugar amounting to 15 per cent, from such a must a drinkable wine could never be obtained, but wher., by the addition of an equal volume of water, we bring this must to a normal acidity of 0.6 per cent and to each 1,000 parts of the mixture add 125 parts of sugar, we have 2,000 parts of a must, which, with a sugar volume of 20 per cent, corresponds to the vintage of an average year, and after fermentation will yield a drinkable wine.

STEEL POWER TRANSMISSION POLES.

A NEW TYPE OF POLE FOR HIGH VOLTAGES.

To carry the high voltage transmission lines of a western power company a special type of steel pole has been designed. The power is transmitted on two circuits of three wires each, carrying a current of 100,000 volts. In view of this high voltage, and the consequent danger to life and risk from fire involved, great care was exercised in selecting the particular class of poles to be adopted.

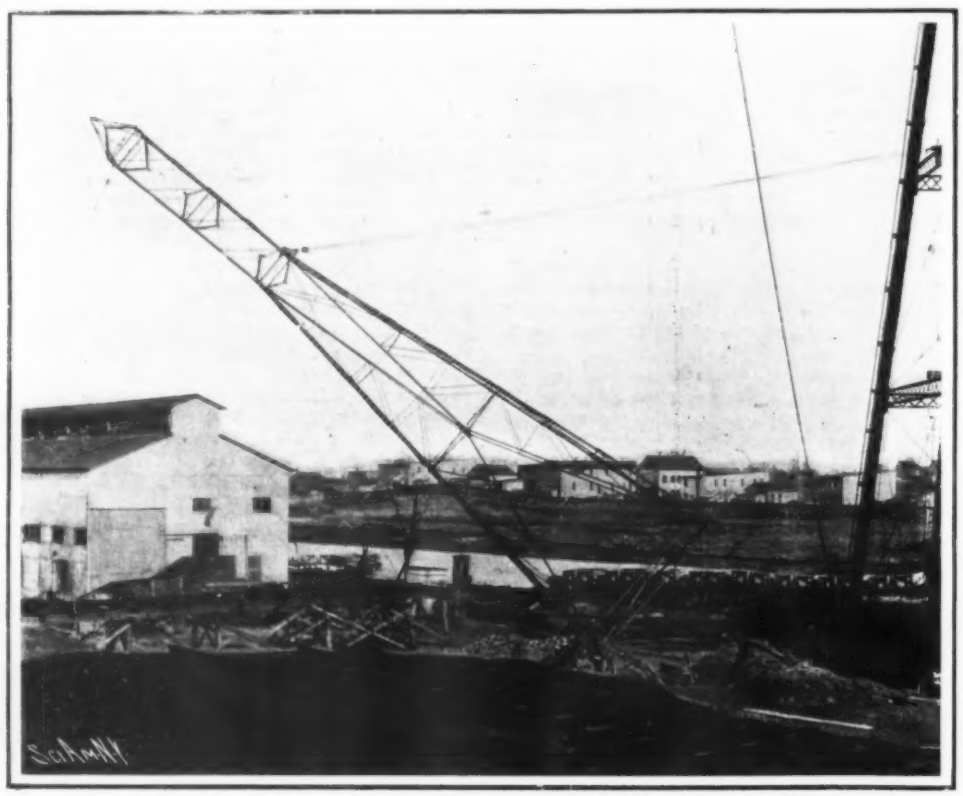
The pole adopted is designed with three cross-arms, it being intended to carry a feed wire on the outer end of each cross-arm by suspended insulation. The top of the pole is arranged to take a guard wire. The poles are intended to be used about 750 feet apart. The bottom of the lowest cross-arm is 51 feet 2 inches above the ground level, and the second cross-arm is 10 feet above the first, and the third cross-arm is 10 feet above the second; the extreme top of the pole carrying a guard wire is 5 feet 1 inch above the bottom of the highest cross-arm. The feed wires are 17 feet 1 inch from each other in a horizontal plane for the two upper cross-arms, and 18 feet 1 inch for the lowest cross-arm; thus making all feed wires 6 feet 5 inches from the nearest part of the pole proper measured in a horizontal direction. The bottom of the pole at the ground level occupies a base 17 feet square. The stub ends of the pole (the portion of the pole in the ground) are separate pieces of steel, and are of such length as to allow of six feet for bedding in the ground.

These poles are constructed entirely of structural steel shapes, and are designed to follow the theoretical stresses and produce a pole of given strength and stiffness with a minimum amount of material. There are a great many duplicate pieces, thus making it a simple matter for the purchaser to put the same together in the field.

Very complete and careful tests of the strength of these poles were made before their regular manufacture was started. The pole was erected in a vertical position on an immovable concrete foundation. The strains were applied by means of weights hanging from a fixed structure, and the amount of load and deflection were easily determined. The pole was designed to stand the following tests: When tested in a vertical position, on an immovable foundation, and with a proper margin of safety, a simultaneous horizontal side pull of 1,000 pounds at the top and 2,500 pounds at each of the three cross-arms, or in other words, a total strain of 8,500 pounds, the cross-arms were to support a suspended weight of 1,000 pounds at their extreme end, and any one of the cross-arms to carry at one of these ends a horizontal pull along the line of 3,000 pounds.

The receivers of Milliken Brothers, Inc., New York city, are manufacturing these poles at their plant in Staten Island, where complete arrangements have been made in the bridge and structural shops for getting out this particular class of structural work. As all of this material (except bolts and nuts) is galvanized by the hot process before shipment, and after all the shop work has been done, there has been added to the Milliken plant a large galvanizing department for doing this particular work. In fact, it is unique in that it has the largest hot galvanizing bath ever constructed. This bath is capable of taking pieces somewhat over 30 feet in length at a single dipping, which is a decided improvement over the old-fashioned method of dipping long pieces one end at a time.

SIDE VIEW OF THE POLE TAKEN PARALLEL WITH THE CROSS ARMS.



THE POLE DURING ERECTION, SHOWING STIFFNESS OF THE STRUCTURE.

The poles are all put together with bolts, and to reduce freight charges are shipped "knocked down." One of the illustrations shows a pole partly erected, and illustrates that these poles are stiff enough in themselves to stand being erected in one piece, thus obviating the necessity of erecting them piecemeal from the ground up.

THRIFT IN AMERICA.

Some statistics published by the Monetary Times of Toronto are interesting as indicating the progress of thrift in America. The habit of thrift is especially apparent there. Living is higher than in Europe, and wages are higher, but both the United States and Canada make a creditable show in the matter of savings bank deposits. There are nearly 8,000,000 savings depositors in the United States, the deposits amounting to more than $3,500,000,000. At the close of 1906 the average savings in the United States was about $41.13 per capita, based upon a total population of 84,500,000 persons, compared with $34.89 per capita five years ago. The average amount of money due to each savings depositor at the close of the last calendar year was $433.79, which compares with $412.53 at the close of 1902. The savings depositors now represent a little more than 10 per cent of the total population, which is double the number of ten years ago. In 1871 there were in Canada 231 post office savings banks, and 17,153 open accounts with a credit of $2,497,260. In 1905 there were 989 savings banks, and 165,518 open accounts, with a credit of $45,368,321, increases of 328 per cent, 865 per cent, and 1,713 per cent. In the same period the cash deposits of the Dominion government savings banks had increased from $556,669 to $2,817,267, a gain of $2,260,598, or 406 per cent. Taking the business of the post office and government savings banks together, the total deposits in 1886 were $15,158,296. In 1896 this sum had decreased to $11,882,307. In 1905 it showed an increase, the total deposits then being $13,574,471. But while the annual deposits of the government savings banks have declined during the past twenty years or more, those of the post office savings banks, until the past two years, increased steadily. The policy of the Dominion government is to close their savings banks as occasion offers. A little over a year ago there were twenty-three government savings banks, now there are only nineteen. In a few years there will probably be only three or four. Of late years the annual deposits of the post office savings banks have been less than the annual withdrawals, the figures for 1905 being $10,504,430 and $12,129,101 respectivelv Much of the money withdrawn from the government banks finds its way into the coffers of the chartered banks. They offer the public advantages which the government institutions do not. For example, the depositor with a bank may obtain his savings without notice. Then again the Canadian banks advertise largely and there is keen competition for business. There are thirty-five chartered banks in the Dominion each striving for the best business. The deposits of the government savings banks in the last twelve months declined to the extent of 0.2 per cent, while those of the chartered bodies gained by 10.5 per cent. The government has some thousand offices in which to transact the savings bank business, the banks have some 1,700 branches in Canada. At the end of March the government savings banks accounted for $14,766,828 deposits, while the post office savings banks held $46,897,724. The March bank statement shows deposits in the chartered banks of $657,961,220.

To summarize, the savings of the Dominion are held as follows:

Deposits in—	
Chartered banks	$567,937,052
Post office savings banks	46,897,721
Government savings banks	14,766,828
City and district savings banks	19,945,511
Caissie d'Economie	8,414,108
	$657,961,220

The following table shows that bank deposits keep pace with the increasing population:

	1891.	1901.	March, 1906.
Population (approximate)	4,833,239	5,371,315	6,371,315
Total bank deposits.	193,015,474	390,949,482	687,961,220
Deposits per capita.	40	73	131

Against the figures of the United States the Canadian deposits per capita look well:

	1905.	1906.
Canada	$95.00	$131.00
United States	39.00	41.00

Canada is not only very prosperous, she would seem to be very thrifty.

NEW METHOD OF CONCRETE CONSTRUCTION.

A NOVEL WAY OF BUILDING SMALL DWELLINGS.

BY C. C. CROSSLEY.

WHILE it seems certain that wood must yield place to concrete as a building material, the expense attached to the latter method of construction is not yet so moderate as to allow of its universal adoption. I have devoted much attention to the possibilities of concrete, and have developed a practical method of building which reduces its cost below that of similar wooden construction. Fig. 1 shows the method of working, and its simplicity. Nos. 2 and 4 show the outer and inner centerings for the wall. No. 1 shows a part of the concrete wall after the outer centering has been removed.

The inner centering (No. 4) is made of ⅞ sheathing lumber nailed to a 2 x 4 spruce frame; it is built in panels 5 feet wide, so as to be easily handled by two men. The wood is coated with crude oil to prevent the concrete from sticking, and this acts as a preservative to the wood, preventing shrinking or swelling. With care, the panels will last for years. The outside centering (No. 2) is of 2-inch, squared spruce plank, and as the wall is built and sets the lowest plank is removed and placed on top. The planks are held in position by bolts which go through the wall and are fastened on the inside centering. No. 3 are cores to give an air space and insure dryness. These

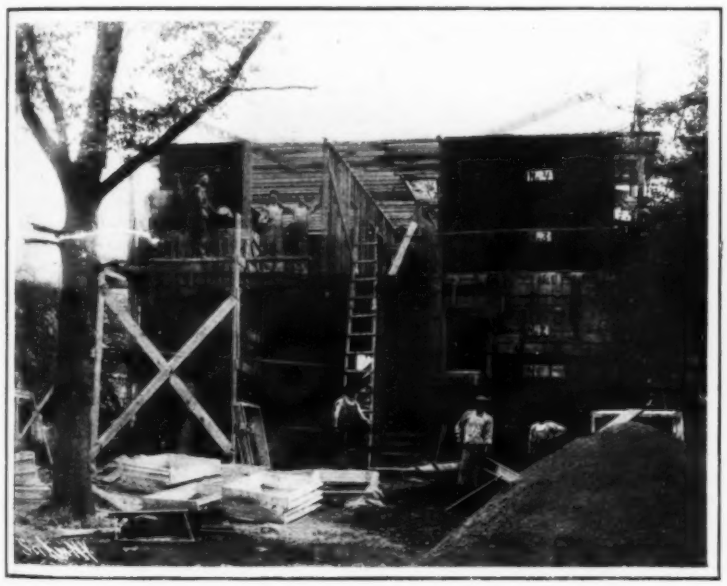


FIG. 1.—THE METHOD OF BUILDING, SHOWING OUTER AND INNER CENTERING AND CENTRAL CORE.

FIG. 2.—A FINISHED HOUSE BUILT AT MAMARONECK BY THE NEW METHOD OF CONCRETE CONSTRUCTION.

are placed between the centerings, diagonally, and slightly overlapping, and as the wall rises they are pulled higher, leaving a continuous air space from the base to the top of the walls. No. 5 is a frame for a casement window. These frames have a false member nailed on the outside face, and after they are set in position the false pieces are moved, leaving a concrete molded finish around the outside. This not only sets off the work, but entirely prevents any possibility of air drafts between the concrete and the wood casement.

The concrete should be thoroughly mixed, stirring it horizontally, and should be very sloppy. Do not add more than a foot in height to the walls at any one time, and never try to pound the concrete down into the mold. When it has set for a little while it is safe to move the lowest board and add another tier. The finished work will come out as smooth as the lumber used to mold it. All wood fastenings are tacked to the face of the inside centering and should be beveled on both edges except in the angle between the walls and ceiling, so as to bind into the concrete. When the centering is removed, the walls may be at once whitecoated, thus effecting a saving in the cost of finishing.

The air space in the walls renders them dampproof; and windows and door frames, being concreted into the wall, are wind-proof.

For hollow walls or flues, I have designed a metal contracting core, which can be removed after the concrete has set. I have patents pending on the method of construction and on the cores.

The illustrations show two stages in the construction of houses which I am building at Mamaroneck, near New York.

THE CONSERVATION OF OUR NATURAL RESOURCES.*

By GIFFORD PINCHOT, of the U. S. Bureau of Forestry.

THERE are certain renewable resources and certain resources which are not renewable at all. The non-renewable resources are the minerals. What may happen in the case of thousands of centuries hereafter does not interest us at all. We know that when the coal is gone, so far as we are concerned, it is gone for good, and we have a supply of anthracite for about only fifty years.

Not only that, but in certain kinds of coal mining, and some men say that the average will bear out the statement I am about to make, only about half the coal in the ground is actually mined before the roof is allowed to fall in, and what remains is permanently inaccessible for all time to come. In other words, our methods of mining are such as to eliminate from consideration at the start one-half of that which is absolutely indispensable as a necessity for our present kind of civilization.

What may happen in the future it is difficult to predict, but we know, so long as present methods continue, that coal is a necessity, and we know that the supply of coal is limited, and we are acting as if it made no difference whatever that that supply should be exhausted.

Of the 50 per cent which is mined, on an average about 90 per cent is wasted; or, to put it in another way, only about 10 per cent, and in many cases only five per cent, of the energy of the coal is actually transformed into work.

The sum total remains that under our present methods an excessively small quantity of the value of the coal to all our people is ever put to use, and there is in such a statement as this, a very serious indictment of our whole people; and with all due allowance for the necessities of the case, for the rapidity with which we have reached this stage, there is a definite indictment of the intelligence of our people as a whole for that, judging from the point of view of the single individual.

What should any of us say of a man adrift at sea in an open boat with a little barrel of water, or with a keg of water, enough water to last him with ordinary use for five days, and he knew that the chances of his being picked up at sea were infinitesimal, he was out of the track of ships, and he knew with the best time he could make it would take twenty days to reach land, what should we think of that kind of a man if, under these circumstances, he not only drank all the water he wanted, but used the rest of it to wash his hands? And yet we are not only using all the coal we want, but we are throwing a lot of it away.

We have handled natural gas in precisely the same way. The great flambeaux have been kept burning day and night, year in and year out, in certain gas fields, until what had been foreseen as an inexhaustible supply, and so described until people really came to believe it, was all gone. How many oil fields of the United States are already exhausted, and with the utmost hopefulness in forecasting the discovery of new fields, is it not fairly reasonable to suppose that within a comparatively short time, the oil, too, will have gone the way of much of the gas?

In no other case except that of the forests have we as a people so distinctly emphasized our lack of foresight as we have in the case of the mineral fuels, and the result is especially important, because in our present state of civilization we must have them to go on with our work. We ought to have known better, and the time is easily come, when, instead of the limitations which are imposed upon us by commercial conditions, we ought ourselves, as a nation, to grasp this question of mineral fuels definitely and attempt its definite and foresighted regulation. It is one of the great problems which we must meet, one of the most difficult ones, and one of the most essential ones; for, when our mineral fuels are gone, so far as we can see now, the only practicable source of power will be sun power or water power, and will be difficult to use for many of the purposes for which coal is now employed. We have done, to some extent, this thing with our metal ores, but I will not dwell on that aspect of the subject.

There are a good many other types of conservation which we must keep in mind in relation to the land. For example, it has been said over and over again, and correctly, that the greatest tax a farmer has to pay is the tax levied on his land by the rain. In other words, it costs him more year by year for the land carried by erosion from the surface into the streams than it does to pay any other tax which falls upon him; and a singular beauty of our methods of cultivation which allow this are well illustrated by the fact that after the farmer has lost this soil from the field where it belongs, it goes down into the channels of the rivers, where it does not belong, and costs the nation millions of dollars to take it out. If there ever was a loss that cut both ways it is this loss of soil from the farmer.

If we have been shortsighted in the matter of mineral fuel, we have been vastly more shortsighted in the matter of the forests. Wood is not less necessary to our present civilization than coal, and the best figures which the Forest Service has been able to obtain (doubtless they are not correct) is that at our present

* From an address to the American Institute of Electrical Engineers in New York.

rate of consumption we have standing timber for only about twenty years, and in this connection it is well to add, just as in the case of the man floating in the open boat, that there is no other supply from which we can expect to meet our demands. The Canadians are coming to need all the wood they have; so with the Mexicans. South America is a wonderfully rich continent in forests, but to import timber from that country means that it would be at an expense vastly greater than that of timber grown at home.

We have permitted ourselves to get into a condition where a timber famine is not only likely, but certain, and where the best we can expect to do is to mitigate the famine somewhat, but how much we can mitigate it I do not yet know. How much the use of reinforced concrete and the use of steel and the employment of other construction will help cannot be said, but that these will help to a great extent there can be no doubt. The curious fact remains that there never has been a large substitute for wood, and it is a peculiar fact with the employment of these other methods of construction that there is vastly more wood used for construction in the United States to-day than when all the construction was of wood; in other words, we are in a place where we must suffer, and in this case we must pay the bill.

Fortunately, it is not altogether too late, because the forest is a renewable resource, and so we have a chance to correct the faults of the past. That we are trying to do. We have about 165,000,000 of acres of national forests established in the West, and shall have others in the East, and naturally these forests will be brought to the point where they will produce the most timber possible from their physical situation, but we cannot expect to meet from one-fifth of the forests of the United States a demand which is exceeding five-fifths, and which is consuming that five-fifths three times faster than it is being produced. In other words, there is distinctly trouble ahead. I said a little while ago that a change in public sentiment was the essential and indispensable factor in this movement of conservation. It is nowhere truer than in the case of the forests. Four-fifths of the forests are in priv te hands, and unless the owners of these four-fifths will join in the movement to minimize the timber famine, use their forests rightly, we shall have vastly more trouble than we shall have if they help.

It is certainly true that as our forests are destroyed at the headwaters of our streams, our water powers suffer, the navigability of our streams suffers, irrigation suffers, and the domestic and manufacturing water supply suffers. Wherever our streams flow, and they flow from wherever the stream rises in the mountains or in the forests, and they do so pretty much all over the country, there forest preservation is just as important because of the streams as it is because of the other services which the forest renders.

We have been equally shortsighted in allowing great monopolies to be formed for the use of water power from these streams without the possibility of government control. The idea is growing that it is a fair thing which should win, that the interest of the people at large is greater than the interest of any single man or single body of men less than all the people, and that when Uncle Sam gives us his natural resources it is no more than fair that he should acquire the use of them in a way to do as much good on the one side and as little harm on the other as possible

THE LATEST WORK ON THE SOLAR PARALLAX.

PROGRESS MADE IN A COLOSSAL TASK.

BY ABBÉ MOREUX.

THE colossal task undertaken in 1900 by nearly all the great observatories of the world under the direction of M. Loewy and the French Academy of Sciences is making rapid progress. The object of this article is to give the latest results of the calculations and to show the degree of confidence which they deserve.

An idea of the uncertainty in regard to the value of the solar parallax that prevailed before 1900 may be obtained from a comparison of the following extracts from the Nautical Almanac:

Date.	Authority and Method.	Solar Parallax, in Seconds.	Distance of Sun.	
			Kilometers.	Miles.
1801-1833	....	9	147,100,000	91,410,000
1834-1859	Encke, transits of Venus	8.5776	153,400,000	95,320,000
1870-1881	Le Verrier, inequalities of lunar parallax	8.95	147,950,000	91,930,000
1882-1900	Newcomb, general mean	8.848	148,850,000	92,475,000

The last value 8.848 sec. was derived by Newcomb from a very laborious discussion of all the methods employed up to that time, and represents the most probable mean of the following values:

	Sec.
Newcomb: Observations of Mars in 1862	8.855
Hall: Observations of Mars in 1862	8.842
Hansen, Stone, and Newcomb: Inequalities of lunar parallax	8.838
Newcomb: Lunar equation of the earth	8.809
Powalky: Transit of Venus in 1869	8.832
Struve's value of the constant of aberration combined with Foucault's value of the velocity of light	8.860
Most probable value of solar parallax	8.848

It might well have been expected that this value would be final but it proved to be nothing of the sort. The uncertainty which prevailed in regard to the solar parallax led the directors of the four great nautical almanacs—French, British, German, and American—to meet in Paris in 1896 for the purpose of adopting a uniform series of astronomical constants, beginning with January 1, 1901. This international conference had at its disposal the following additional values of the solar parallax:

	Sec.
Gill's heliometric measurements of asteroids	8.802
Aberration of light	8.799
Inequalities of lunar parallax	8.794
Mass of the earth deduced from secular variations of the four inferior planets	8.759
Mass of the earth deduced from the motions of Venus alone	8.762

As Gill's measurements were by far the most certain of all and as his value differed very little from the values obtained from the parallactic inequalities of the moon and the aberration of light, the value 8.80 sec. was adopted for the solar parallax, and this value was inserted in the almanacs for the first years of the twentieth century.

This decision had hardly been reached when serious opposition began to manifest itself in various quarters. Even before the almanac for 1901 had come into use one of the leading advocates of the adoption of the value 8.80 sec. proposed the following very different series of values:

	Sec.
Gill's measurements of asteroids	8.802
Aberration of light	8.77
Inequalities of lunar parallax	8.77
Mass of the earth derived from secular variations	8.759

Here the probabilities are 3 to 1 in favor of a value of 8.77 sec. or less, while in the preceding table the probabilities were 3 to 2 in favor of a value of about 8.80 sec. Indeed, it was generally suspected, after 1898, that the adopted value, 8.80 sec., was too large.

At this juncture came the memorable discovery of Eros, and as this asteroid would be very near the earth in the winter of 1900-1 it was agreed to make use of this favorable opposition for the solution of the problem. From 67 measurements of photographs taken at Northfield observatory, Wilson concluded that the solar parallax was very nearly 8.80 sec. Hinks, of Cambridge, obtained from 295 photographs taken at nine observatories a value of 8.797 ± 0.0047 sec., which in the case of a positive error would give 8.8017 sec., a value which differs very little from the value adopted in the nautical almanacs. Since this announcement was made the discussion of the photographs of Eros taken at Greenwich has been completed. The resultant provisional value of the solar parallax, as communicated to the Royal Astronomical Society, is 8.800 ± 0.0044 sec. This value was obtained from measurements of 151 plates made with the astrophotographic telescope of 13 inches aperture and 103 plates made with the Thompson 26-inch telescope, between October 14, 1900, and January 15, 1901. These three values derived from Eros agree very closely with each other and also with the mean of all values obtained since 1825, as computed by Dr. Weinberg: 8.804 ± 0.00243 sec., and with Sir David Gill's value: 8.802 ± 0.005 sec.

It appears, therefore, that the value 8.80 sec. is not as erroneous as has been supposed. What, then, is the explanation of the discrepancies and differences of opinion?

Direct astronomical methods have always given higher values than those obtained by indirect methods. The whole question hinges on the degree of confidence to be accorded to the different methods. It is evident, *a priori*, that the solution of the problem should be sought by direct astronomical mensuration. If the values thus obtained do not agree with the results of indirect methods the burden of proof rests on the advocates of the latter.

For example, the value of the solar parallax deduced from the aberration of light increases by 0.44 sec. for each decrease of 1 sec. in the value of the constant of aberration. The accepted value of this constant is 20.54 sec., and the corresponding value of the solar parallax is 8.773 sec. If the parallax has been proven, by direct methods, to be 8.80 sec., the obvious inference is that the current theory of aberration is false and that the phenomenon is more complex than has been assumed. Similarly, to quote Prof. Hinks, if new researches confirm the conclusion that 8.76 sec. is the only value of the solar parallax that can reconcile the current theory of planetary motions with the observed value of the constant of gravitation, the contradiction between the direct and indirect methods may lead to the discovery of the defects in that theory, which now make impossible a complete explanation of the movements of the solar system.

In these circumstances the best course will be to endeavor to perfect the various methods, in order to eliminate all sources of error and make the results strictly comparable. The complete discussion of all the data furnished by the observations of Eros in 1890-1 will give a value of the solar parallax affected with a probable error not exceeding one-thousandth of a second. But this is not enough, and Sir David Gill has already appeared with a demand for still greater precision.

In 1931 Eros will approach the earth within 16,000,000 miles, about half the distance that separated the two planets in 1900, and Gill asserts that it will then be possible to determine the solar parallax to one ten-thousandth of a second. He adds that preparation for this great astronomical event should begin at once. The cause of the systematic errors affecting some of the photographs should be discovered, special photographic reflecting and refracting telescopes constructed, and the stars near the path of Eros in 1931 accurately charted with the aid of these instruments. The comparison of the positions of these stars, as obtained with different instruments, will enable the true position of Eros, without systematic error, to be found, if all the instruments agree, and will reveal the sources of error if they do not agree. As Eros will describe a very long path during the opposition of 1931 it will be desirable to begin at once the meridian observations required to fix the positions of the reference stars to be used in the measurement of photographs.

The magnitude of this undertaking makes it necessary to distribute the work among all the meridian observations of the world. For this reason Sir David Gill proposed, last August, that a congress of astronomers be convened without delay for the purpose of considering the work to be done in preparation for the opposition of Eros in 1931. If the hope of this eminent astronomer is fulfilled we shall know the sun's distance to within 10,000 miles—little more than the diameter of the earth.—Translated for the SCIENTIFIC AMERICAN SUPPLEMENT from Cosmos.

Gold-Purple Ink.—*a*. Sodio-chloride of gold 1 part, water 10 parts, gum 1 part. *b*. Tin salts 1 part, water 100 parts, gum 10 parts. *a* for writing, *b* for preparing textiles. *a*. Gold is dissolved in strong hydrochloric acid, to which, from time to time, some nitric acid is added, until all is dissolved; to 4 parts of hydrochloric acid about 1 part of nitric acid is required. Concentrate it by evaporation, dilute it with water and while warm add a solution of oxalic acid, which causes the precipitation of the gold in the form of a fine brown powder. The pure gold, after being washed out, is again dissolved in a mixture of hydrochloric and nitric acids, and the solution mixed with common salt. On concentration by evaporation, we obtain crystals of sodio-chloride of gold.

FORMATION OF MINERAL VEINS.—I.

ANALYSIS OF ROCKS AND THE METALS EXTRACTED FROM THEM.

BY DR. WILLIS EUGENE EVERETTE.

THE ANALYTICAL COMPOSITION OF THE SURFACE ROCKS OF THE EARTH.

1. In any thesis relating to the genesis of the formation of ore veins—i.e., mineral veins, or zones, lodes, dikes, veins, and "blossoms," of the metalliferous petrolic materials that are found in the fissures and shattered crevices of the surface rocks in the crust of the earth—it is important to first understand the chemical composition and the structural character of the *rocks* in which these ore veins are found.

2. In so far as we actually know, by definite physical observation, geological investigation, and chemical analysis of the rocks from the deepest mines and shafts that have been sunk in the crust of our earth, we find that *granite* is the basal rock of the earth.

3. This petrolic and analytical information is also corroborated by the upthrusted bedded strata and massive rocks of the Laurentian and Appalachian ranges in America, as well as by the similar geological conditions found in the Canadian Rocky Mountains, which, if piled vertically on each other, would show a geological section fully thirty miles in thickness of former bedded strata.

4. The deepest shafts that have been sunk from the surface downward in the crust of our earth are about one mile in depth, or about the 1/4,000 part of the total depth of the earth, from its surface to its center.

5. The mineralogical composition of granite is quartz, felspar, and mica. Quartz (or, for the sake of euphony in the nomenclature of rocks, I have taught my students to call it silicite) is a compound of oxygen and silicon. Felspar is a compound of quartz (or silicite) together with the alkalies, such as sodium, potassium, magnesium, calcium, and, very rarely, lithium, to form what are called silicates of the alkalies. Mica is a double silicate of an alkali, together with iron or manganese, and rarely with some other elements, though usually only iron is the added element. The common form of mica is named muscovite, and crystallizes into foliated or leaflike very thin planes, easily separated from one another. In its total mass as a crystal it often assumes the shape and angles of other solid and massive, hard-rock crystals. Black mica, as biotite, is very much harder and more solid than muscovite, resembling more in hardness the adjacent quartz and felspar in the granite mass.

6. By the decomposition and disintegration of granite, and the recomposition again with its own metamorphic changes, together with a slight admixture of the other adjacent elements found in the earth's crust, all rocks that we have ever seen are the certain results of the recomposition of a metamorphic (or changed in form) original granite.

7. Sand is only crushed quartz (or silicite) in the shape of small grains and dust. Clay is only a mixture of silicates of alkalies, together with water, iron compounds, and alumina. Earth (as mold, muck, etc.) is only a mixture of clay and sand along with varying amounts of vegetable matter. The various rocks (whether sedimented or volcanic) are only a mixture of the changed form of the quartz, felspar, and mica, from the original granite combined with water and a portion of the exceedingly small amounts of other chemical elements that are in the rocks.

THE CHEMICAL ANALYSIS OF THE ROCKS.

8. The chemical analysis of the constituents of the rocks of the crust of the earth will show an average analysis approximating as follows:

	Per cent.
1. Oxygen (O)	47.15
2. Silicon (Si)	27.87
3. Aluminium (Al)	8.12
4. Iron (Fe)	4.72
5. Calcium (Ca)	3.54
6. Sodium (Na)	2.67
7. Magnesium (Mg)	2.65
8. Potassium (K)	2.34
	99.06

9. Practically, the rocks of the crust of the earth consist almost entirely of quartz and quartz compounds, aluminium compounds, iron compounds, limestone and dolomite, and earthy alkalies; and over three-fourths of the earth's crust is composed of oxygen and quartz.

10. To this analysis is now added the exceedingly slight amount of those other elements in the rocks that are in about, or are in excess of, the 1/100 part of one per cent of the total mass of these terrestrial surface rocks. For the exact chemical data we have regarding those elements which are less than the 1/100 part of one per cent in quantity in the rocks of the crust of the earth is not sufficiently definite to give us much actual knowledge as to whether they increase in quantity or not, as we go below the earth's surface. Nor do they in any manner affect the result of the total analysis of the surface rocks, or cause us to make very much material change in their elemental composition.

11. Of the hundreds of analyses made of the rocks of the crust of the earth, the following analysis is a fair average quantity of those elements which are below one per cent, but also are above the 1/100 part of one per cent of the total mass of the surface rocks of the earth. And this analysis will therefore show that gold, silver, copper, lead, zinc, tin, antimony, arsenic, cadmium, cobalt, bismuth, platinum, palladium, osmium, iridium, selenium, tellurium, and tungsten, etc., are *not even included* in the analysis submitted of the surface rocks of the earth's crust, and are thus (in varying greater and lesser proportions) very much less than the 1/100 part of one per cent of the rocks, or much less than two-tenths of one pound (avoirdupois), or less than 1,400 grains (avd.), to one ton of 2,000 pounds (avd.) of the rocks, when compared to the total mass of the available rocks of the earth.

	Per cent.
1. Titanium (Ti)	0.30
2. Hydrogen (H)	0.16
3. Carbon (C)	0.15
4. Phosphorus (P)	0.09
5. Manganese (Mn)	0.08
6. Sulphur (S)	0.07
7. Bari[illegible]	
8. Chr[illegible]	
9. Nick[illegible]	
10. Stro[illegible]	
11. Lith[illegible]	
12. Chlo[illegible]	
13. Fluo[illegible]	
Total analysis	99.06
	0.94
	100.00

AVAILABLE METALS THAT ARE OBTAINED FROM THE ROCKS.

12. Oxygen cannot be obtained in its metallic form as it is then, when metallic or solid, in an icelike mass at the normal temperature of the rocks of the earth, because oxygen will only liquefy from its ordinary gaseous condition at a temperature of about 320 deg. below Fahrenheit zero; and will only solidify into an icelike mass from its liquid condition at a temperature of about 400 deg. below Fahrenheit zero. However, when oxygen is in union with silicon, aluminium, and some other elements, it will combine as a solid crystal, or as a rock, or as a mineral compound, but is not then a metal; and although over 47 per cent of the crust of the rocks of the earth consist of oxygen, by the reasons as heretofore described, it cannot be obtained as a commercial metal.

13. Silicon is not native as a metal in the rocks of the earth. By a temperature of the electric arc light, or about 7,000 deg. above Fahrenheit zero, the silicon of quartz may be separated from its compounded oxygen, and then can be poured and cast, looking like brittle and very hard molten zinc in appearance. So avid is it, however, for oxygen, that even red-hot silicon will absorb some of the oxygen from the atmosphere, and an immediate invisible film of crystalline quartz (or silicite) covers it from any further oxidation for a considerable time. Silicon, as a metal, or as a silicide of iron and carbon, is formed in steel to a slight degree; but for practical purposes, although being over 27 per cent of the crust of the rocks of the earth, by reason of its enormous affinity for oxygen, and the high temperature for its extraction, it is not regarded as a commercial metal.

14. Aluminium is not native as a metal in the rocks of the earth, but it is the most abundant metal that, if we desired, we can obtain from the rocks. Over 8 per cent of the total mass of the rocks of the crust of the earth is aluminium. But so great is the affinity of this aluminium to hold onto its compounded oxygen, silicon, iron, and alkalies (as in its usual mineral condition it is a silicate of aluminium) that it requires a most intense heat, and the high temperature of the electric arc, before it will let go of its closest affinity, that is, its oxygen content, that it is nearly always found with. The ordinary silicates of aluminium are sapphire, ruby, corundum, emery, beauxite, and cryolite, depending on the iron, chromium, manganese, barium, water, and alkaline additions to the original compound of aluminium, oxygen, and silicon that it is found with. It is, therefore, not so important a metal, or commercially as available a metal, as its next neighbor in proportion to quantity, that is, the metal which is named iron.

15. Iron is rarely found native as a metal among the rocks, and is then always found associated with nickel, and is then evidently of purely meteoric origin, and not, directly speaking, of native terrestrial origin. Although iron is less than 5 per cent of the total mass of the rocks of the crust of the earth, it is the most plentiful metal that we can commercially obtain from the rocks of the earth. This is due to the fact that its oxygen content (as it is usually found as an iron oxide or an iron carbonate) is easily separated by heat together with alkalies and carbon, at the economically obtained temperature of the ordinary blast furnace, or about 2,900 degrees above Fahrenheit zero. Its oxygen content, having a greater chemical affinity for molten alkalies than it has for the iron, when combined with molten alkalies and incandescent carbon at a temperature of nearly 3,000 deg. F., will let go of the iron and combine with part of the carbon to form carbonic monoxide and then thereafter form carbonic acid, and then a portion will combine with the alkalies and the silicon present in the furnace charge, to form alkaline silicates as slags. The iron then assumes a liquid state, and by its high gravity sinks down through the lighter molten alkaline silicates in [illegible] preceding paragraph.

16. Calcium is not found as a metal among the rocks. It can, by intense heat, be obtained as a silvery-yellow metal, but on account of its great affinity for oxygen it cannot be kept in a permanent metallic condition in the presence of either the oxygen of the atmosphere or the oxygen of water. It is usually found in the rocks combined with oxygen and carbon, as a carbonate of calcium, and is then called limestone and marble. It is also found as the double carbonate of calcium and magnesium, and is then named dolomite. These compounds are therefore different from the silicate of the alkaline lime, when as a lime-soda felspar of the original granite rock; for the silicon has now been eliminated, and carbon has taken its place and combined with the oxygen, usually forming such combination as the rock called limestone. The escaping silicon during the process has combined with more oxygen, and has formed sandstone, flint, chert, quartz, jasper, and the other silicious rocks, which are always found associated with both limestone and dolomite.

17. Magnesium is not found native as a metal among the rocks. It, however, can be obtained as a metal of very light specific gravity; but its close affinity for oxygen is sufficiently great to cause it to easily absorb oxygen from the air, and change it slowly into a white, powdery oxide of magnesium, that is called magnesia. When exposed to an open flame, in its powdered metallic state, it will instantly combine with the oxygen of the air, and form an explosive flash of intense white flame, and change into a dense white smoke of oxide of magnesium. In quantity among the rocks of the earth, in its various compounds, as dolomite, etc., it is about 2½ per cent of the total mass of the rocks of the crust of the earth. Asbestos is a form of a fibrous silicate of magnesia.

18. Potassium and sodium are never found as metals among the rocks. They both can be obtained in their metallic states from any of their compounds as soft, waxy, silvery-white solids by a commercial method of distillation. But their affinity for oxygen is so enormously great, and their oxygen absorption is so rapid, and such a large amount of heat is evolved during this process of combining with the oxygen, that both sodium and potassium when in their metallic state will draw out the oxygen content from water, so extremely rapidly and with such intense evolved heat that the remaining hydrogen content of the water

escapes in a gaseous condition, and is instantly ignited, burning a portion of the sodium with a yellow-colored flame and a portion of the potassium with a violet-colored flame; in other words, actually setting the water on fire, and burning the water as a fire burns a piece of dry paper.

When either metallic sodium or metallic potassium is freshly cut, like a soft wax, and exposed to even dry air, it rapidly absorbs oxygen from the air and becomes covered with a white coating of an oxide of itself, and is soon entirely changed into an oxide form. For preservation as a metal, therefore, they both must be kept immersed under any liquid free from oxygen, such as gasoline or kerosene. Sodium is about 2 2/3 per cent of the total mass of the rocks of the earth's crust, and potassium is about 2 1/3 per cent of the total mass of the rocks.

19. Therefore, as we have now taken out over 99 per cent of the constituents of the rocks of the crust of the earth, we find that the actual available metallic content thereof is limited to practically only two elements that can be commercially used (in our atmosphere) as metals. That is, out of the 99.06 per cent of the elementary and petrolic materials that we can obtain as rocks from the crust of the earth, iron and aluminium are the only two elements that we can use for commercial and practical purposes as metals when they are exposed to the oxygen of the air or exposed to the oxygen of water.

20. (1) And such metals and non-metals, with which we are so familiar, as titanium, hydrogen, carbon, phosphorus, manganese, sulphur, barium, chromium, nickel, strontium, lithium, chlorine, and fluorine, are found in the remaining 0.94 of one per cent of the constituents of the rocks of the crust of the earth, and all in exceedingly small quantity when compared with the iron and aluminium content of the rocks. (2) However, in reference to the *carbon content* of our "rock analysis," we do not include herein the carbon of the coal compounds, or of graphite, or of petroleum, or of ozokerite, all of which we will again refer to in a succeeding paragraph under the head of coal. (3) In relation to the hydrogen content of our ultimate analysis of the rocks, we find that among the constituents of the rocks of the crust of the earth, there is about 0.16 per cent of hydrogen. Now, as we find that 0.12 per cent of hydrogen will combine with 0.88 per cent of oxygen to form the compound called *water*, it then follows that about 1.33 per cent of water is combined in the total rock mass of the crust of the earth as a combination of hydrogen and oxygen. This, of course, does not include the springs, creeks, rivers, lakes, and oceans of water that are among the fissures of the rocks or are in the bowls, sinks, or depressions in the rocks; because such waters are not, strictly speaking, any part of the rock mass of the crust of the earth, but are only temporarily occupying the fractures and depressions therein, and are continually changing their environment by evaporation, movement, absorption, and many other metamorphic changes.

21. The remaining metals that we are daily accustomed to see, such as gold, silver, copper, lead, zinc, tin, antimony, arsenic, bismuth, cadmium, selenium, tellurium, platinum, tungsten, iridium, palladium, etc., are in such minute quantity when compared to the total mass of the rocks, that we cannot include them at all in our analysis of the rocks, except in hundredths, thousandths, and tens of thousandths of decimals of a per cent. And yet their actual visible quantity in commercial and laboratory uses is so large, that we can scarcely realize what a very small percentage they are to the total mass of the rocks of the earth, as we look at them.

22. This fact, then, will prepare us to realize the reasons why the metallic rock materials are so widely scattered and diffused among the strata of the crust of the earth, and why some ore veins are rich—by concentration of this metal material from an enormous quantity of an adjacent rock mass—and why so many ore veins are lean and more or less barren of metal materials, so that we can scarcely work them at all economically for commercial purposes.

(To be continued.)

Brilliant Gold for the Decoration of Porcelain, Glass, and Earthenware (according to Chalian de Moriès).—Pure gold is dissolved in nitro-muriatic acid and oxide of uranium added to the mixture, to give the gold tint a more or less brownish shade. A bichloride is formed of gold and uranium, which is evaporated to dryness in the sand bath. After it is cooled, mix 1 part of gold-uranium preparation, 0.5 part of sulphur powder, 1 part of gum dammar, 3 parts of rectified oil of turpentine, melted together in a porcelain dish, over a lively fire and well stirred until the mixture is complete and begins to assume a fine, reddish brown color. Then oil of rosemary is added and it is not set to cool until it has acquired the consistency of a thick syrup. Previously there must be added to the bright gold the ordinary bismuth flux, 0.3 to 0.4 part to 1 part of gold metal. The preparation, in its thick fluid condition, can be kept for a long time.

ENGINEERING NOTES.

The New York Central announced recently the restoration of the eighteen-hour schedule between Chicago and New York for its Twentieth Century Limited train. The schedule was temporarily abandoned last December, when one hour was added to the running time. The change took effect on April 19, the train leaving Chicago at 2:30 P. M., and arriving in New York at 9:30 A. M., eastern time. Returning, the leaving hour is 3:30 P. M. and the arrival in Chicago 8:30 A. M.

The pig iron production in the United States in 1907 was 25,781,361 gross tons, according to the American Iron and Steel Association. This amount was 1.9 per cent greater than that of 1906, and would have been still larger but for a decrease of production in the last part of the year, which continued into January, 1908, during which month the output was below that of any other month since January, 1904. Canada produced 581,146 tons in 1907.

The proposals for aiding drydock companies submitted by the government to the Canadian House of Commons will, if adopted, give new drydocks a subsidy or bonus equal to three per cent on the cost of the works, to be paid for in twenty years, the limit to any one concern being fixed at $45,000 a year. Owners of existing drydocks who wish to enlarge them are to be given a large subsidy also for twenty years, but the total is not to exceed $15,000 a year. The Canadian government now gives subsidies or bonuses to railway builders, steamship lines, manufacturers of steel and iron, smelters of lead, to owners of petroleum wells, spinners of binder twine, to cold-storage warehouses, and to shipbuilders.

According to a contemporary Mr. A. Hiorth, of Christiania, has obtained a patent in Norway for a process of working up gangues, such as are left behind after numerous metallurgical operations, and consist of intimate mixtures of graphite and silica. Such material has hitherto been found of no value, but the idea of the present inventor is to crush it, mix it with lime and iron scrap, and also with some compound of iron, if necessary, and, finally, to fuse the whole in an electric furnace. A reaction is then stated to proceed among the ingredients whereby calcium carbide is formed from the lime added and the carbon present, while the silica is converted into ferro-silicon. If the raw material should contain too little gr phite to yield calcium carbide and the equivalent quantity of carbon monoxide, some form of carbon should be added to it in suitable amounts.

A cannon ball was recently found on the farm of L. Myers, West Manheim Township, Pa., a few hundred yards from where the "Mary Ann furnace" was located in 1762. Although worn and rusted with dirt and age it was still a "solid shot." As local historians are aware, a meadow four acres in area of land was purchased in 1762 and during the same year a furnace was built—called "Mary Ann furnace." The cause of the building of this furnace where it was is said to have been on account of the abundance of chestnut timber in that vicinity, which was burned into charcoal and used in smelting the ore. During the revolutionary war, while the Continental Congress was in session in York, this furnace was put to use in manufacturing cannons and balls for the American army. Some of these balls (as the one recently found on Mr. Myers's farm indicates) are scattered over the fields near where this furnace was located. They vary from the size of a marine ball to the four-inch cannon ball. Where the furnace stood piles of cinders are yet seen. This historic furnace, which was a business venture and existed about forty years, is said to have been a financial failure.—Hanover correspondence York Gazette.

Arrangements have been completed for the construction of a railroad up Table Mountain, Cape Town, for the purpose of expediting transit to the summit from the city below. The civic authorities have arranged to grant a concession for the construction and operation of the railroad together with a hotel at the top, with the option of purchase as a municipal asset at the expiry of twenty-five years, the idea being to develop the mountain summit as a pleasure resort. Although several restrictions are imposed, the type of railroad is left open to the concessionaires. In view of the fact that the water supply of Cape Town is derived from a suitable point on the mountain side, access to which is secured by means of an aerial cableway, care is being exercised to protect the area and gorges carrying the water to the city from pollution, while at the same time the natural beauties of the mountain are not to be impaired in any way. It is anticipated that such a railroad would be successful from the financial point of view, since it would not only be patronized by the inhabitants of the surrounding neighborhood, but also by the many thousands of passengers who touch at the Cape *en route* to India, the East, and Australia, and who having several hours at their disposal during coaling and shipment and discharge of freight, would avail themselves of the opportunity to ascend the mountain.

TRADE NOTES AND FORMULÆ.

Varnish for Bright Gold.—*a*. A varnish made from 16 parts of sulphur, 16 parts of turpentine, 80 parts of oil of turpentine, 50 parts of oil of lavender, to which is added: *b*. 30 parts of gold dissolved in nitro-muriatic acid (aqua regia) precipitated through zinc, with 1.2 parts of antimony butter and mixed with 500 parts of water.

To Make Grain Sacks Durable.—Ten parts of good oak tanbark are brewed in 140 parts of boiling water. In this decoction the sacking is immersed and left there for twenty-four hours. Then the fabric is taken out, rinsed in clear water, and allowed to dry. It is possible to reckon on about eight yards of sacking to 2 pounds of tan. The tannin penetrates into the flax and hemp fibers, and not only protects them against moldiness, but increases their durability.

Tannery Refuse for Ink Making.—The water bailed out of the pit is placed in a kettle and boiled down to about one-fourth of its volume. From this it is transferred to a cask where it remains undisturbed for about twenty-four hours and can become clarified. The clear liquid is drawn off and to it is added green vitriol and some gum (2 to 5 parts of green vitriol to 230 parts of fluid). From the last vessel the ink is transferred to large, open pots, where it should remain about three weeks.

Perforation of Glass.—Use a steel drill, moistened with turpentine. (The drill must have a long point and plenty of clearance.) To file glass use a 12-inch mill file, simple cut and moistened with oil of turpentine. Large holes can be cut more rapidly with a tubular steel tool, made like a file at the end or with teeth. It is as well to back the glass with a sheet of lead, to prevent breakage by uneven pressure.

Imitation of Ground Glass.—1 part of ground white lead in a mixture of 0.75 part of varnish, with 0.25 part of oil of turpentine. To the mixture, as a drying medium, add burned white vitriol and sugar of lead. The color must be made very thin at first and be spread on the glass plate with a broad brush, as evenly as possible. Should the windows require a new coating, the old must first be removed by the application of strong lye, made from potash, or one can rub on a mixture made from 2 parts of hydrochloric acid, 2 parts vitriol, 1 part sulphate of copper (blue vitriol) and 1 part gum Arabic by means of a brush.

According to the Mechanical World, an English firm has lately been experimenting with the object of producing a file which will do more work and last longer than files made from ordinary tool steel. The outcome of these experiments is a new special chrome-steel file. These files have recently been tested at Sheffield, with excellent results. The total number of strokes made with the file tested was 270,000, the strokes per minute being 51, and the number of hours 88¼. The amount of filings removed during this time was 10½ pounds. The makers, W. Atkins & Co., Ltd., Sheffield, England, claim that this is far in excess of any result known at the present time, and that it represents a marked advance in the cutting power and ability of files.

Drink Temperatures.—Food and drinks will be found most grateful to the palate at the following temperatures:

	Deg. Fahr.
Drinking water	54
Seltzers or soda water	57 to 61
Beer	57 to 61
Red wine	62 to 68
Light white wine	59
Heavy white wine	50
Champagne	46 to 50
Coffee and tea	102 to 124
Coffee and tea, to quench thirst	50 to 64
Meat broth	90 to 125
Milk	61 to 64
Milk (cow-warm)	93 to 95
Soup, with flour and pulse (legumes)	98 to 125
Food in paste form	98 to 109
Or perhaps	118
Roasted meat	98 to 109

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